PROCEEDINGS

TWENTY-SEVENTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

Wemme, Oregon

March 1-4, 1976

Not for Publication

(For Information of Conference Members Only)

Prepared at

Intermountain Forest and Range Experiment Station
U.S.D.A. - Forest Service
Ogden, Utah 84401

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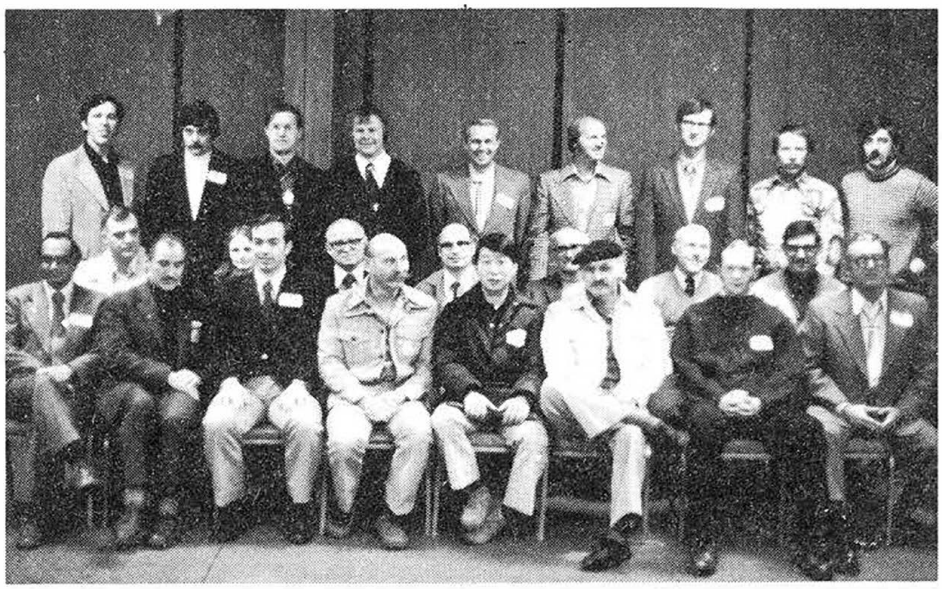
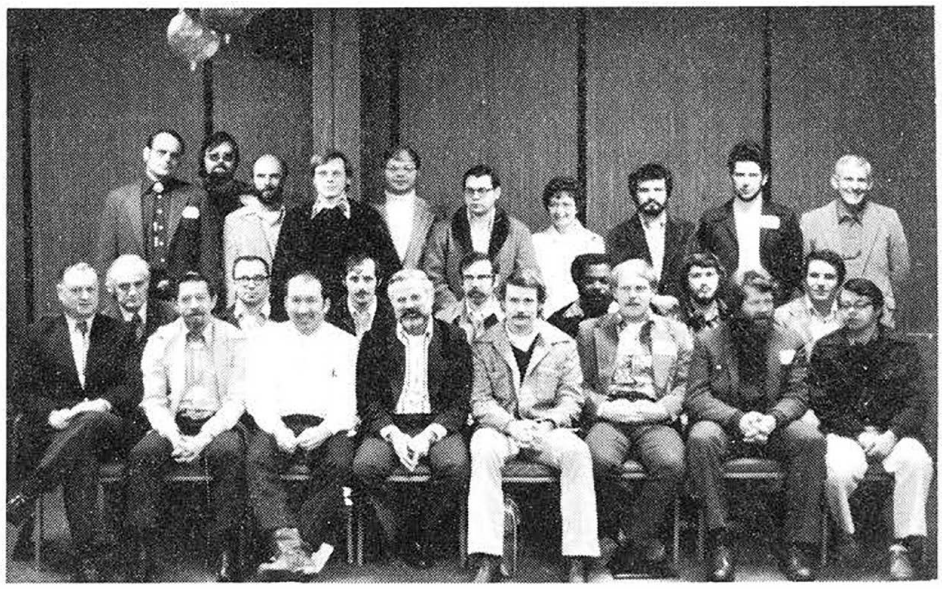


Back row (l. to r.): H. Osborne, _____, J. Richerson, I. Weatherston, R. Beckwith, R. Lyon, R. Acciavatti, J. Knopf, A. Berryman.

Middle row: D. Leonard, S. Jensen, K. Wright, W. Bousefield, W. McCambridge, T. Koerber, J. Foltz.

Front row: P. Nigam, A. Randall, _____, G. Trostle, H. Yang, R. Johnsey, S. Cade, P. Pulley.



Back row (l. to r.): W. Ciesla, E. Nebeker, G. Amman, B. Baker, B. Roettgering, L. Stipe, L. Clark, J. Wenz, J. McLean, R. Mason.

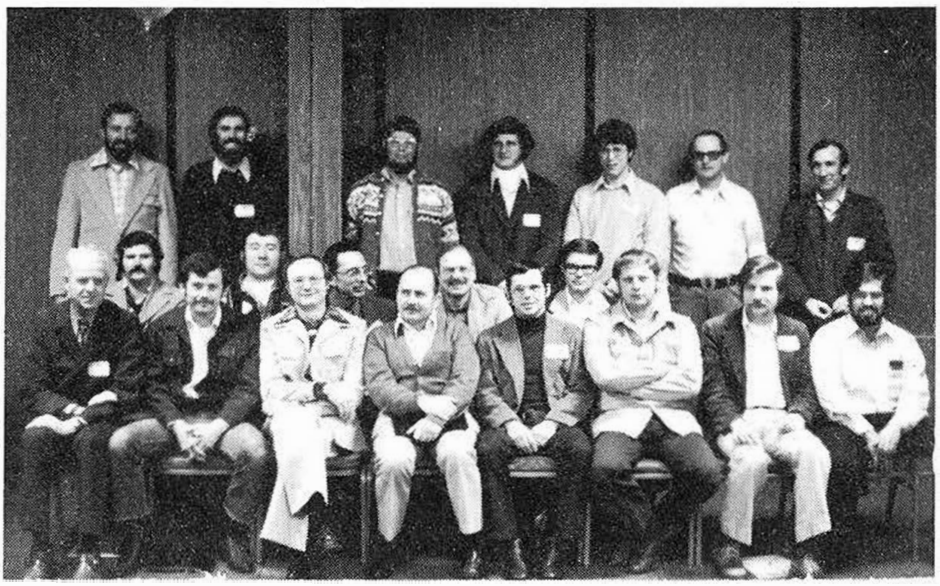
Middle row: J. Rudinsky, _____, L. Rasmussen, R. Billings, R. Wiggins, G. Daterman, D. Overhulser.

Front row: B. Maksymiuk, W. Cole, J. Schmid, D. Cahill, J. Logan, D. Kulhavy, D. Dahlsten, M. Atkins.

Back row (l. to r.): R. Hunt, _____, B. Hynum, M. McGregor, L. Abrahamson, J. Hard, B. Hostetler, _____, G. Howse, R. Schmitz, P. Shea.

Middle row: R. Mitchell, D. Ward, T. Jasumbach, T. Flavell, M. Furniss, _____, R. Ryan.

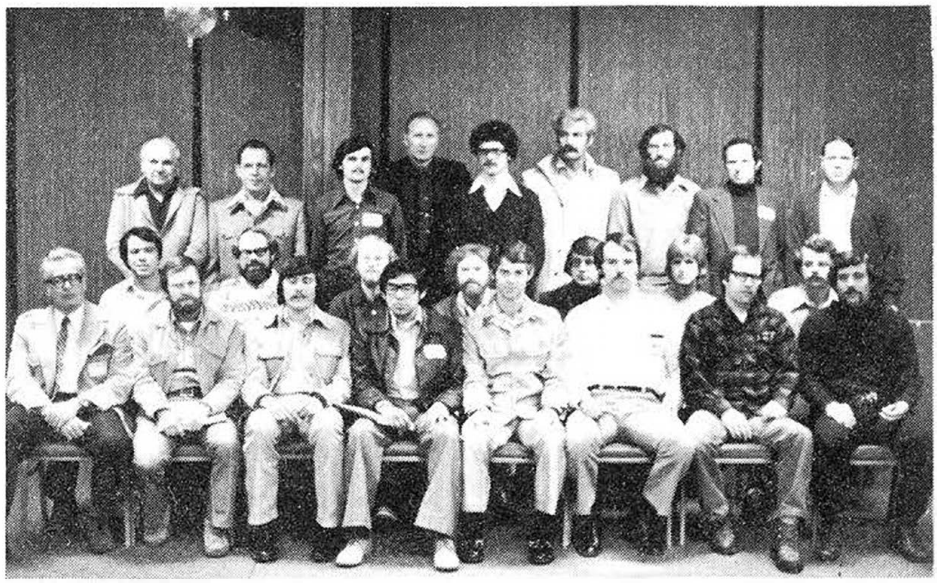
Front row: J. Schenk, L. Pettinger, D. McComb, J. Wortendyke, T. Gregg, F. Shon, H. Anderson, A. Valcarce.



Back row (l. to r.): W. Klein, N. Crookston, A. Smith, E. Lessard, _____, R. Washburn, W. Evans.

Middle row: W. Salazar, J. Caylor, K. Shea, B. Dolph, K. Knauer.

Front row: J. Wear, P. Joseph, L. Kline, J. Pierce, P. Gravelle, R. Blair, R. Clausen, M. Brown.



Back row (l. to r.): A. Larsen, L. McMullen, R. Mahoney, S. Tunnock, L. Frandsen, W. Copper, _____, J. Dewey, S. Kohler.

Middle row: D. Leatherman, R. Werner, L. Wright, J. Hansen, D. Hamel, _____, C. Ohmart.

Front row: W. Waters, W. Brewer, R. Celaya, D. Cibrian, D. Parker, R. McKnight, T. Payne, F. Stephens.

Back row (l. to r.): V. Carolin, M. Stock, M. Stelzer, M. McKnight, R. Luck, R. Coulson.

Front row: H. Thompson, C. DeMars, G. Simmons, M. McFadden, J. Colbert, B. Wickman, _____.

PROCEEDINGS

TWENTY-SEVENTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

Wemme, Oregon

March 1-4, 1976

EXECUTIVE COMMITTEE (Twenty-Seventh WFIWC)

G. C. Trostle, Portland	Chairman
R. E. Stevens, Fort Collins	Immediate Past Chairman
G. D. Amman, Ogden	Secretary-Treasurer
R. G. Cox, Lewiston	Councilor (1973)
L. Safranyik, Victoria	Councilor (1974)
D. L. Parker, Albuquerque	Councilor (1975)

B. E. Wickman, Corvallis — Program Chairman

EXECUTIVE COMMITTEE ELECT

R. L. Johnsey, Olympia	Chairman
G. C. Trostle, Portland	Immediate Past Chairman
L. N. Kline, Salem	Secretary-Treasurer
L. Safranyik, Victoria	Councilor (1974)
D. L. Parker, Albuquerque	Councilor (1975)
S. C. Cade, Klamath Falls	Councilor (1976)

J. R. Carrow, Victoria — Program Chairman

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* Summary not submitted

PROGRAM

Twenty-Seventh Annual
Western Forest Insect Work Conference

Bowman's Resort
Wemme, Oregon

March 1-4, 1976

Monday, March 1

4:00 p.m. - 8:00 p.m.	Registration
8:00 p.m.	Executive Committee Meeting

Tuesday, March 2

8:00 a.m.	Late Registration
8:30 a.m. - 9:15 a.m.	Initial Business Meeting
9:15 a.m. - 9:30 a.m.	Coffee Break
9:30 a.m. - 12:00 Noon	Panel: The Spruce Budworm. Moderator: Mel McKnight, Forest Service, Washington Office. Western Situation: Bob Dolph, Forest Service, Pacific Northwest Region, Portland, Oregon Maine Situation: Pete Orr, Forest Service, Upper Darby, Pennsylvania. Canadian Research Approach: Gordon Howse, Canadian Forestry Service, Sault Ste. Marie, Ontario. Planning Committee Report: Boyd Wickman, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon.
12:00 Noon - 1:00 p.m.	Lunch

1:00 p.m. - 5:00 p.m.	Concurrent Workshops
	Modeling and Dynamics of Budworm Populations. Moderator: Dave Leonard, University of Maine, Orono, Maine.
	Defoliator Pheromones--Chemistry and Application. Moderator: Gary Daterman, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon.
	Chemical Testing Against Defoliators. Moderator: Robert Lyon, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.
	Potential and Problems with Biocontrol of Defoliators. Moderator: Dick Schmitz, Intermountain Forest and Range Experiment Station, Moscow, Idaho.
	Current Approaches to Continuing Pest Problems. Moderator: Les McMullen, Canadian Forestry Service, Victoria, B.C.
6:00 p.m.	Buffet
Evening	U.S.--U.S.S.R. Forestry Exchange Program--A Glimpse of Forest Insect Research in the Soviet Union. Mel McKnight, Forest Service, Washington Office.
	Chinese Forest Entomology. Ross McDonald, Canadian Forestry Service, Victoria, B. C.

Wednesday, March 3

9:00 a.m. - 12:00 Noon — Concurrent Workshops

Population Sampling--Estimation, Evaluation and Prediction.
Moderator: Bill Waters, University of California, Berkeley, California.

Microbial Testing Against Defoliators.
Moderator: Roy Shepherd, Canadian Forestry Service, Victoria, B.C.

Chemical Control of Spruce Budworm--Pro and Con.
Moderator: Bill Klein, Forest Service, Intermountain Region, Ogden, Utah.

Economical and Sociological Assessment for Bark Beetles.
Moderator: Donn Cahill, Forest Service, Rocky Mountain Region, Denver, Colorado.

Silvicultural Prescriptions for Dendroctonus Beetles.
Moderator: John Schmid, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Detection, Monitoring and Survey Methods.
Moderator: Steve Kohler, Montana Division of Forestry, Missoula, Montana.

12:00 Noon - 1:00 p.m. — Lunch

1:00 p.m. - 3:00 p.m. — Panel: USDA Combined Forest Pest R&D Program--Organization, Status and Plans
Moderator: Keith Shea, USDA, Secretary of Agriculture's Office, Washington, DC.

Southern Pine Beetle: Bob Thatcher, Program Manager, Pineville, Louisiana.

Gypsy Moth: Tom McIntyre, Program Manager, Hyattsville, Maryland.

	Tussock Moth: Ken Wright, Program Manager, Portland, Oregon.
3:30 p.m. - 10:00 p.m.	Buses to Timberline Lodge, National Historical Site. Tours, Buffet Dinner, Night Skiing.

Thursday, March 4

9:00 a.m. - 12:00 Noon	Concurrent Workshops
	Bark Beetles--Opportunities and Limitations of Pheromones. Moderator: Mike Atkins, San Diego State University, San Diego, Calif.
	Sequential Sampling--Does It Work for Forest Defoliators. Moderator: Douglas Parker, Forest Service, Southwestern Region, Albuquerque, New Mexico.
	How to Measure Impact of Defoliators. Moderator: Wayne Bousefield, Forest Service, Northern Region, Missoula, Montana.
	How Do We Put Technology to Work. Moderator: Bill Ciesla, Forest Service, Davis, California.
	What Will Population Models Do For Us. Moderator: Walter E. Cole, Intermountain Forest and Range Experiment Station, Ogden, Utah.
	Pest Management R&D Programs--Questions and Answers. Program Managers, USDA
12:00 Noon - 1:00 p.m.	Lunch
1:00 p.m. - 2:00 p.m.	Final Business Meeting
2:00 p.m. - 4:00 p.m.	Transportation to Portland International Airport

WESTERN FOREST INSECT WORK CONFERENCE

MINUTES OF EXECUTIVE COMMITTEE MEETING
March 1, 1976

Chairman Trostle opened the meeting at 8:15 pm at Bowman's Mt. Hood Resort, Wemme, Oregon. Those present: Galen Trostle; John Schmid, representing immediate past chairman Bob Stevens; Roy Shepherd, representing Councilor Les Safranyik; Program Committee members Boyd Wickman, LeRoy Kline and Roy Beckwith; and Gene Amman.

The registration fee was discussed. Motion MSC that fees for this meeting be set at $8 for regular members and $3 for student members.

Keeping the membership roster up to date was discussed. We have 232 active members and 52 inactive. Members who become inactive this year will be polled to determine their status.

Location of the 1978 meeting was discussed. An invitation was received from Colorado. The 1977 meeting will be held in Victoria; Rod Carrow will be program chairman.

It was noted that a nominating committee should be appointed to make nominations for positions of chairman, secretary-treasurer, and one councilor to replace Royce Cox whose term expires at this meeting.

Ethical practices chairman McCambridge will choose members to serve on this important committee.

The executive committee knew of no member being deceased during the past year. If the membership knows of anyone, please inform the secretary.

The executive committee is concerned that recent restrictions on meeting attendance by both the United States and Canadian governments threatens the concept of our work conference. Restrictions on attendance greatly limit the exchange of ideas among people working on common problems. Because of this concern the committee suggests the subject be raised for discussion in the initial business meeting.

Chairman Trostle adjourned the meeting at 9:30 pm.

WESTERN FOREST INSECT CONFERENCE

MINUTES OF THE INITIAL BUSINESS MEETING
March 2, 1976

Chairman Trostle called the meeting to order at 8:35 am, Bowman's Mt. Hood Resort, Wemme, Oregon. Minutes of the 1975 final business meeting and the treasurer's report were read and approved. The treasurer reported a balance of $1,203.54 at the beginning of the 1976 meeting.

Minutes of the executive committee meeting were read. Concern over attendance at the Work Conference was expressed and this subject was opened to discussion. It was felt that restrictions were generally made at higher political levels, although at times local restrictions are also imposed for financial and political reasons. Keeping the Work Conference categorized as such in contrast to a formal paper reading meeting has been a continual problem.

Motion MSC that a letter be sent to Assistant Secretary Robert Long of the USDA, and the Canadian Minister of Environment Jeanne Sauves reemphasizing objectives of the work conference. Ken Wright volunteered to help draft such a letter. It was suggested that the letter might include such items as (1) the number of persons working in forest entomology, (2) a copy of the proceedings, and (3) that members consider the meeting so important that some attend at their own expense. In addition, it was suggested that some of the same ideas should be presented in meeting announcements.

Chairman Trostle appointed a nominating committee consisting of Les McMullen, Chairman; Bob Luck, Gary Pitman, and Bill Klein. Nominations for chairman, secretary-treasurer, and councilor are in order.

Victoria, B.C. is the 1977 meeting site. Donn Cahill proposed somewhere in Colorado, probably Durango, as the 1978 meeting site.

Red McComb, representing Bill Ives, Chairman of the Common Names Committee, reported that terms of all members of this committee have expired. Chairman Trostle charged the nominating committee with establishing a new 7 member committee with staggered terms of duty.

There being no further business, Chairman Trostle adjourned the meeting at 9:15 am.

WESTERN FOREST INSECT WORK CONFERENCE

TREASURER'S REPORT

Balance on hand February 22, 1975		$ 767.09
Received from Registration (Monterey Joint WFIWC & WIFDWC)	$3,492.00	4,259.09
Expenses for 1975 meeting	2,282.75	1,976.34
Preparation of Proceedings	710.51	1,265.83
WIFDWC share of balance	77.29	1,188.54
Gifts for secretaries who typed 1971, 72, and 74 Proceedings	30.00	1,158.54
Received membership fees	45.00	1,203.54
Balance on hand March 1, 1976		$1,203.54

U.S./U.S.S.R. FORESTRY EXCHANGE PROGRAM: A Glimpse of Forest Insect Research in the Soviet Union

M. E. McKnight
USDA-Forest Service, Washington, D. C.

In August 1975, a team of U.S. scientists representing the Forest Service, USDA, and universities visited the Soviet Union as part of the U.S./U.S.S.R. Science and Technology Agreement, Working Group on Forestry[1/]. The purpose of our discussions was to initiate a program of information exchange and cooperative research on the subject of "Integrated Control of Forest Pests and Diseases." The working plan, developed through earlier negotiations, includes the following specific topics for cooperation:

1. Integrated control of gypsy moth.

   (a) Methods of gypsy moth assessment and forecasting of populations.

   (b) Methods and techniques of gypsy moth control with the use of attractants.

2. Improvement of microbiological and chemical methods for control of forest insects.

The Team consisted of: John B. Simeone (Leader), Department of Entomology, State University of New York, Syracuse, New York; Melvin E. McKnight, Forest Insect and Disease Research Staff, Forest Service, USDA, Washington, D. C.; Franklin B. Lewis, Northeastern Forest Experiment Station, Forest Service, USDA, Hamden, Connecticut; David E. Leonard, Department of Entomology, University of Maine, Orono, Maine.

Accompanying the Forest Insect Research Team throughout our itinerary were Mr. Fiodor S. Kuteev, Chief of the Forest Protection Laboratory of the All-Union Scientific Research Institute of Silviculture and Mechanization of Forestry at Pushkino, Moscow Region, and Mrs. Rita Nikitina, Laboratory of Patent Research and Technical Information Service, of the same Institute, the latter serving as translator and interpreter. During the first week and at various times later, we were joined as well by two additional entomologists, Mr. Pavlin A. Zubov and Mr. Vladimir S. Znamensky, both senior scientific workers in forest protection at the same Institute.

1/ McGuire, John R. 1974. U.S./U.S.S.R. Forestry Exchange Program. J. Forestry 72(2): 74-77.

After initial conferences with the State Forestry Committee of the U.S.S.R. and the All-Union Research Institute of Silviculture and Mechanization of Forestry, the U.S. Forest Insect Research Team proceeded on an itinerary which included laboratories in Ufa, Bashkir ASSR; Kharkov, Ukraine SSR; and Benderi and Kishinev, Moldavia SSR; all having been chosen for their active involvement with the gypsy moth problem. A brief visit also was paid the Forest Ministry of the Ukraine SSR at Kiev, but no laboratories or scientists were visited, this portion of our previously agreed upon exchange having been attentuated due to time restrictions and the temporary absence of plant protection specialists who were attending the International Congress on Plant Protection in Moscow.

Our discussions concentrated upon the gypsy moth, but some exchange took place on other forest insect problems, and on questions of management and silviculture, especially during our field visits to forested areas. Our hosts were particularly interested in comparing systems of management, measurement tools of silviculture, and the achievement of multiple use of the forest.

There seemed to be traditional reverence throughout the several Republics that we visited for the forest as a resource of unquestionable value to the public. Our visit was frequently accentuated with emphatic expressions on the importance of protection of the forest with such pronouncements as "saving every chlorophyl-producing leaf," "preservation of the green," and "saving our forests" with seemingly little concern for the economic cost-benefit parameters that we in the United States have adopted to justify actions against pests in recent years.

Often, in reference to pest control, there was expressed a responsibility of our generation to future generations not only of the Soviet Union but of all the world. Whether or not this was influenced by the fact that only a few days earlier Soviet cosmonauts and the American astronauts had joined their vehicles in outer space is difficult to estimate. The cooperative venture in space served often as a basis for conviviality, friendship, and motivation for joint efforts in research.

The U.S. Forest Insect Research Team found the Soviet scientists technically competent, adequately staffed and equipped, and obviously enthusiastic over possibilities for cooperative research with U.S. counterparts. Research on the gypsy moth appears largely oriented toward development of population trend prediction methods and specific control measures such as chemical and microbial insecticides. The integrated control approach was especially impressive. There is probably less progress toward mathematical modeling of the

gypsy moth-host forest system in the U.S.S.R., but the Soviet scientists appeared aware of the orientation of U.S. gypsy moth research in that direction.

Although the U.S. Team achieved an overview of gypsy moth research conducted by the State Forestry Committee through its Institutes and Experiment Stations, little was learned of related research in the Academies of Science and universities. Also, if research capabilities and progress at Kishinev are indicative, there is much to be learned of microbial and attractant research in Institutes of other Ministries.

Little insight was gained into research on and pest management approaches to forest pests other than gypsy moth and associated hardwood defoliators. This was due largely to the specificity of the Working Plan for cooperation. The gypsy moth is clearly not the most important forest insect in the Soviet Union, as it is not in the United States. Both countries would benefit considerably from information exchange on other pest problems, especially insects of pine, spruce, and larch forests.

PANEL: THE SPRUCE BUDWORM

Moderator: M. E. McKnight

Panelists: R. E. Dolph, G. M. Howse, D. E. Leonard, G. Simmons, B. E. Wickman

Introduction: M. E. McKnight, USDA-Forest Service, Washington, D. C.

Some years ago a member of this Work Conference wrote "The statement 'the spruce budworm is one of the most destructive pests of the coniferous forests of North America,' or its equivalent, appears often in the literature of forest entomology." The destructiveness of the spruce budworm complex is more often assumed than measured in terms of impact (net effects) but the importance of the group is undisputed. The budworms are important because their outbreaks force land managers to decide whether to "do nothing" or "do something." And to "do something" usually involves large-scale application of chemical insecticides and, of course, considerable associated controversy.

Spruce Budworm in the West: Robert E. Dolph, USDA-FS, R-6, Portland, Ore.

Western spruce budworm (Choristoneura occidentalis Freeman) is widely distributed throughout western North America. The first outbreak of this forest insect was reported in British Columbia in 1909. The first outbreak in Western United States was reported in 1922 in Idaho and Yellowstone National Park, Wyoming. Since then outbreaks have been observed in every western State except California. Johnson and Denton report that visible budworm defoliation has been reported in either Idaho, Montana, or Wyoming every year since 1922. When discussing outbreaks I will be referring to the situation where there is a sudden large increase in budworm population. An infestation, on the other hand, refers to an abnormally large population of the insect existing for a long period of time. An outbreak, therefore, proceeds or is the preexpression of an infestation.

The first major infestation was identified in northern Idaho between 1926 and 1933. The next major budworm infestation did not occur until 1943. Since then budworm has been a chronic problem in many Douglas-fir and true fir stands, particularly in Montana and Idaho.

Estimates of acreage of budworm-defoliated forests have been computed annually from aerial surveys in the Pacific Northwest Region since 1947; 1950 in the Northern Region; 1954 in the

Intermountain Region, and since 1956 in the Rocky Mountain Region. The data are shown graphically in Figure 1.

Since the early 1950's visible defoliation has been reported annually in the Northern and Intermountain Regions for the past 20 to 25 years. Elsewhere, budworm damage fluctuated. During the period from 1947 to 1964 visible budworm defoliation was observed annually in the Pacific Northwest Region. Then for a 5-year period between 1965 and 1970 budworm populations subsided to a level that no visible defoliation was observed in either Oregon or Washington. It is of interest to note that budworm activity in Colorado has remained constant except that during 1969 there was a total collapse of the budworm population. No visible defoliation was observed that year, whereas the previous year budworm caused visible defoliation on 177,000 acres. The primary factor cause for this collapse is believed to have been the adverse weather conditions which existed in June 1969.

Although not shown on the graph, budworm was also active in New Mexico and Arizona during the late 1950's and early 1960's. Some 1.2 million acres of Douglas-fir and white fir were being defoliated at that time. Budworm populations in these two States collapsed in the late 1960's and remained endemic until just recently.

It now appears a new budworm cycle is developing in the West. There has been an increase in visible defoliation since 1969. During 1975 more than 6.3 million acres of visible defoliation was observed in Western United States and 283,000 acres in British Columbia (Figure 2). Most of the damage, 4.9 million acres, was located in northern Idaho and Montana.

Elsewhere, budworm defoliation was observed on 733,000 acres in southern Idaho and northwest Wyoming; 532,000 acres in Washington and Oregon; 125,000 acres in Colorado, and nearly 10,000 acres in New Mexico and Arizona.

Egg mass surveys in the fall of 1975 indicate the budworm populations in northern and southern Idaho are starting to decrease after being high since 1966; populations in British Columbia, Montana, Washington, Oregon, northwest Wyoming, New Mexico, and Arizona are increasing; and in Colorado the populations are remaining static.

One of the first attempts to suppress a spruce budworm outbreak in the West occurred 47 years ago. The project was located west of Cody, Wyoming, on the Shoshone National Forest along the road leading to the east entrance of Yellowstone National Park. A lead arsenate-fish oil-water formulation was used as a larvicide

FIG. 1

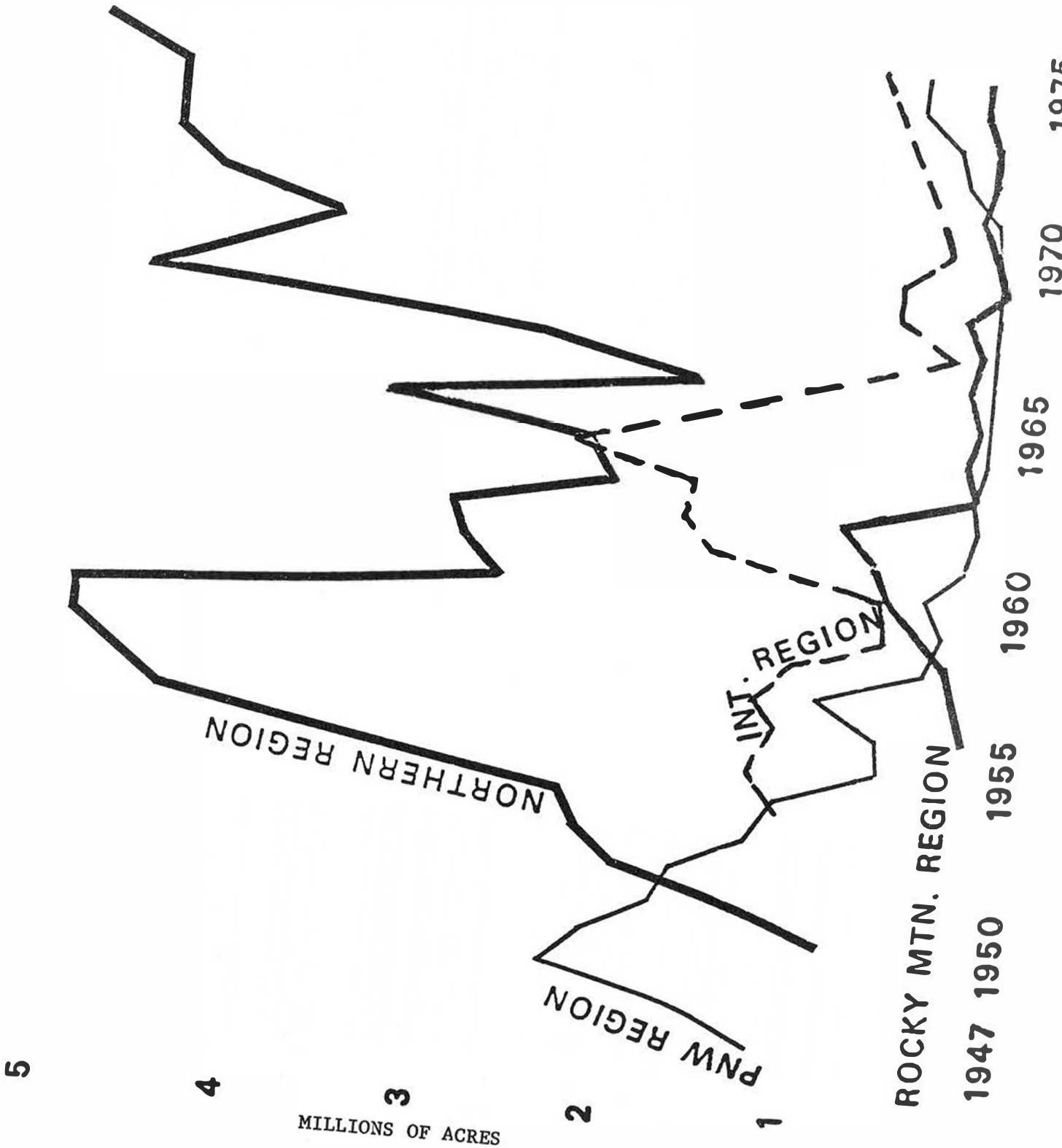

NORTHERN REGION
INT. REGION
ROCKY MTN. REGION
PNW REGION
1947 1950 1955 1960 1965 1970
1
2
3
4
5
MILLIONS OF ACRES

FIG. 2--ESTIMATED GROSS ACREAGE OF HOST FORESTS VISIBLY DEFOLIATED BY BUDWORMS IN WESTERN NORTH AMERICA BY NATION AND U.S. FOREST SERVICE REGIONS IN 1975.

AREA	BUDWORM SPECIES			
	C. occidentalis	C. biennis	C. viridis	C. lambertiana
	--Million Acres--			
CANADA				
BRITISH COLUMBIA	283.0	?		
UNITED STATES				
REGION 1	4,902.0			
REGION 2	125.0			
REGION 3	9.9			
REGION 4	733.0			
REGION 5			12.8	6.4
REGION 6	532.5		28.5	
TOTALS	6,585.4	?	41.3	6.4

and white petroleum oil was used as an ovicide. High pressure hoses and nozzles from truck-mounted sprayers were used to apply the materials. The objective of the project was to preserve the foliage and save the trees in the highly valuable scenic area. The results were minimally satisfactory. Natural control factors are reported to have terminated the outbreak in 1932.

Chemicals were not used again until 1948 to control a budworm outbreak. In that year, the State of Oregon and the Forest Service carried out a pilot control project on 4,500 acres in central Oregon to determine if the new insecticide DDT was effective against the budworm. The results were very good; over 95 percent of the larvae were killed. Based on this result, a total of 267,000 acres were treated in 1949 on the east and west sides of the Cascade Mountains in Oregon.

Since then the Forest Service and numerous States have used aerially applied chemical insecticides in more than 40 experimental and 60 operational programs to control epidemic populations of the budworm on about 13 million acres. The last operational program to control a budworm infestation was in 1966 in Montana and New Mexico. Malathion was used in these projects.

During 1975, the Forest Service carried out several pilot control projects using three insecticides. Region 1 applied Sevin 4-oil and Dylox and Region 6 applied fenitrothion. The primary objectives of this effort were to determine their effectiveness against the budworm and collect data needed for their registration with EPA. Results of the Sevin 4-oil test were favorable and the chemical company has submitted the information to EPA for registering the chemical for use against the western spruce budworm. Dylox results were promising, but additional tests are needed before the material can be registered. Results of the fenitrothion project were unsatisfactory because too many budworm larvae survived the treatments.

This year plans are being made for an operational control project, several pilot control projects, and small-scale field experiments on several different budworm populations in the West.

An operational control project is planned for the Pacific Northwest Region in 1976. The Forest Service, in cooperation with the Washington Department of Natural Resources and the Bureau of Indian Affairs, has proposed to treat budworm on some 291,000 acres in Washington and Oregon. Areas with current high insect populations and previous serious continuous defoliation over 2 or more years are scheduled for treatment. They are proposing to use either malathion, Sevin 4-oil, or Dylox 4. Malathion is

registered for use against the western spruce budworm, Sevin 4-oil and Dylox 4 are registered for use against the eastern spruce budworm. The per acre dosage rates that will be used, depending on insecticide selection are: Malathion at 13 fluid ounces of 95 percent technical AI per acre applied once, Sevin 4-oil at 1 pound AI in a total of 64 ounces of oil carrier-applied once; and Dylox 4 at 1 pound AI in a total of 32 fluid ounces of carrier-applied once. The applications will be made when 50 percent of the larvae are in the fifth instar.

A Draft Environmental Statement was prepared and submitted to the Council of Environmental Quality on January 30, 1976. Selection of the insecticide will be based on public response received during the review process. If either Sevin 4-oil or Dylox 4 is recommended, the Forest Service will apply for emergency use from EPA.

Region 1 is proposing to apply Orthene and Dylox 4 at the 1 pound dosage rates on a pilot control basis. About 12,000 acres will be treated. The materials will also be applied when 50 percent of the larvae are in the fifth instar. The objectives will be to determine the effectiveness of these insecticides under operational conditions; to evaluate how much current year's foliage was saved; to identify and resolve formulation; application and safety problems associated with their use; and to monitor their effects on aquatic invertebrates and fish.

Region 2 is developing plans for a small-scale field experiment using Orthene against budworm on Christmas trees and ornamental trees in Colorado. They plan to use hydraulic sprayers for applying the material. The test design involves two replications plus a check. Four pounds of Orthene in 100 gallons of water will be applied in one area and 4 pounds at peak bud break plus 2 pounds ten days later in another. The objective is to maximize foliage protection. The Insecticide Evaluation Project at Berkeley, California, will be cooperating in this program. They are planning a residue study to determine how long Orthene remains in the new growth.

Region 2 also reports the Rocky Mountain Station may test Dimilin against the budworm. The design and objectives are being developed at this time.

Personnel from PSW Station at Davis, California, are planning a cooperative small-scale field experiment with Region 4 using Orthene at low concentrations and a synthetic pyrethoid. The design and objectives of these tests are being developed at this time.

During the past several years Regions 1 and 4 have been measuring the budworm impact on the forest resource. They plan to continue this effort in 1976. Region 6 plans to establish an impact survey this year.

The objectives of this plan will be to measure the short-term and long-term differences in timber yield, fire hazard, and recreation between treated and untreated areas during the life of the infestation. A secondary objective will test the feasibility of aerial photography to estimate foliage saved and volume impact on the overstory.

In addition to the spruce budworm outbreaks, several other budworm species have caused visible defoliation in various sections of western North America for the past several years. Entomologists in British Columbia report the two-year cycle spruce budworm (Choristoneura biennis) is presently defoliating several thousand acres at several different locations in the Province. This outbreak is expected to continue in 1976.

Officials in British Columbia report control is not planned for either budworm species in 1976. They also report they have been measuring the impact budworm is having on the timber resource in the Province.

There are two additional species of budworm causing visible defoliation in Western United States. They are the Modoc budworm (Choristoneura viridis) feeding on white fir and the sugar pine tortrix (Choristoneura lambertiana) on pine.

The Modoc budworm caused damage on 12,800 acres in northeast California and 28,500 acres in south central Oregon in 1975. In 1974, 143,000 acres were defoliated in California and 90,000 acres in Oregon. Egg samples from these areas in the fall of 1975 indicate the population will continue to decline in 1976. Control is not recommended for either State. In 1974, Region 5 carried out a pilot control project using Dylox. Data indicate Dylox is effective and safe for suppressing Modoc budworm populations.

The sugar pine tortrix defoliated 6,400 acres of pine in northeast California. In 1974, 17,000 acres were damaged in California and 700 acres in Oregon. It is expected this population will also decline in 1976 and control is not recommended. Region 5 reports they are planning a cooperative growth impact study with the Pacific Southwest Station to measure the impact the Modoc budworm has had on the white fir resource in northeast California.

In summary, much work is still needed to develop adequate methods for evaluating the economic and ecologic impacts of budworm outbreaks on the various forest resources. Management needs this kind of data to make sound decisions for or against control. Research is needed to (1) identify the factors which permit budworm outbreaks to exist for long periods, (2) determine if budworm populations can be managed by manipulating tree species, and (3) develop effective and safe pesticides for use under emergency situations.

Spruce Budworm in Canada: Gordon M. Howse, Great Lakes Forest Research Centre, CFS, Sault Ste.Marie, Ont.

The situation: Newfoundland: In 1974, 5.7 million acres suffered moderate to severe defoliation and there was some tree mortality on 300,000 acres. In 1975, 5.3 million acres had moderate-severe defoliation. In 1976, tree mortality is expected on 640,000 acres. No aerial spraying is planned but the Province has initiated salvage programs.

New Brunswick: In 1975, 8.6 million acres had moderate-severe defoliation and 6.8 million acres were sprayed for the Province by Forest Protection Limited. The insecticides used were mainly fenitrothion and dimecron but matacil and dylox were used over relatively small acreages. Egg mass densities have decreased about 32 percent from 612/100 ft.^{2} in 1974 to 411/100 ft.^{2} in 1975. The area of high-extreme hazard covers 12.2 million acres. In 1976, 10-12 million acres may be sprayed.

Nova Scotia: In 1975, 2.2 million acres had moderate-severe defoliation; 427,500 acres of high hazard; no spraying planned.

Prince Edward Island: 600,000 acres of moderate-severe defoliation in 1975.

Quebec: In 1975, 87.4 million acres had moderate-severe defoliation; 40 million acres of high hazard; 7 million acres of tree mortality. Quebec Department of Lands and Forests sprayed 7.1 million acres using fenitrothion, matacil, zectran, dimecron, dylox, dimethoate, and various B.t. formulations. B.t. used on 240,000 acres cost $1,250,000. The results were poor but not much worse than those for chemicals. In 1975, the average egg mass density was 900/100 ft.^{2}, a 50 percent decrease compared to 1974. Quebec plans to spray about 10 million acres in 1976.

Ontario: In 1975, 33.245 million acres had moderate-severe defoliation; 33,360 acres were sprayed by Ontario Ministry of

Natural Resources. Dylox, fenitrothion, and a small amount of B.t. were used. Egg mass counts are down by 57 percent in southern Ontario; 40 percent lower in northeastern Ontario, but 100 percent higher (density doubled) in northwestern Ontario compared to 1974. Moderate-severe defoliation on 40-50 million acres, and 3.3 million acres of tree mortality are expected in 1976. The Province may spray 200,000 to 250,000 acres in 1976.

Summary: (1975)

Province	Moderate-Severe defoliation	Mortality	Sprayed
	----------Acres----------		
Newfoundland	5,300,000	300,000	
New Brunswick	8,600,000	Same	6,800,000
Nova Scotia	2,200,000		
Prince Edward Island	600,000		
Quebec	87,400,000	7,000,000	7,100,000
Ontario	33,245,000	3,300,000	33,360
Totals	137,345,000	10,600,000	13,933,360

Research: Projects active in various regional laboratories and institutes included research on sampling, impacts (on trees), environmental impact of insecticides, experimental control (chemicals against larvae and adults, B.t., IGR's, virus, microsporidia, fungus, parasites, pheromones), simulation model, dispersal, physical factors, nutrition (this work being terminated and switching to feeding rate and genetic studies). In Quebec, NPV carryover from 1971 aerial application increased in 1975 compared to 1974. Infection was 20 to 30 percent causing larval mortality and foliage protection. In Ontario, near Sault Ste. Marie, aerial application of pheromones to a 30-acre white spruce plantation disrupted mating behavior of spruce budworm moths.

Spruce Budworm in Maine: David E. Leonard, University of Maine, Orono

Spruce budworm infestations exist in varying degrees over 5 to 7 million acres in northern and western Maine. As a result, major losses of forest resources--principally spruce and fir pulpwood and small sawlogs--are expected. The Maine Bureau of Forestry proposes to aerially spray 3.5 million acres with insecticide to protect these resources from the budworm at an estimated cost of $3.00 per acre.

About 1.4 million acres or 40 percent of the 3.5 million acre problem area was chemically sprayed in 1975. In 1975, 2,233,500 acres were treated with mexacarbate, fenitrothion, or carbaryl. Budworm populations were reduced an average of 92 percent for all treatments and preservation of current year's foliage averaged 35 percent. Originally, 3.5 million acres were scheduled for treatment, but this figure was reduced due to a lack of sufficient insecticide. Data on the effect of not being able to treat this additional 1.27 million acres are not available.

In 1975, tests were conducted on over 20,000 acres of budworm infestation with Orthene (acephate), Matacil (aminocarb), Dylox (trichlorfon), Lannate (methomyl), Dimilin (TH6040), Reldan, and Bacillus thuringiensis. Each of these materials produced results that were promising. The results obtained with Dylox were so effective that the material was registered in Maine for use in suppressing budworm populations as well as preserving foliage at the dosage rate of one pound AI/acre.

Computer Simulation Model for Spruce Budworm/Forest Management in New Brunswick: Dr. Gary Simmons, University of Maine, Orono

Under sponsorship of Environment Canada, Dr. C. S. Holling and others at University of British Columbia, Vancouver, have assembled a computer simulation model for spruce-fir forests in New Brunswick. With reasonable accuracy, the model mimics the history of spruce budworm outbreaks in New Brunswick from 1950 to 1975. The model can be used to evaluate a variety of management strategies, singly and in combinations, for their results on the forest and on budworm populations over any specified period.

Proposed Spruce Budworms Program: Boyd Wickman, USDA-Forest Service, PNW Station, Corvallis, Ore.

In 1974, PNW Station was directed by the Deputy Chief for Forest Service Research to develop a comprehensive proposal for research to address spruce budworm problems, East and West. The proposal was drafted or reviewed by representatives of Forest Service Research and Pest Management units in the East and West and several universities involved in spruce budworm problems.

The program of research and development activities proposed would make new and improved budworm control and population assessment methods available to land managers. Emphasis would be on development of selective chemical, biological, and silvicultural methods of control with minimal adverse effects on nontarget organisms and the forest environment.

The primary objective of the proposed program is to provide land managers with improved technology in the context of a pest management system with strategies to minimize losses from the spruce budworms. Subobjectives are to:

1. Improve and implement methods for assessing and predicting budworm population levels, subsequent tree damage, changes of stand attributes, and site conditions.

2. Improve existing control technology and develop new chemical, biological, and silvicultural treatment techniques.

3. Develop and implement methods for assessing and predicting short- and long-term impacts on forest resource use and values.

4. Develop strategies for integrating pest and resource management systems.

The program approach would greatly increase cooperation and effectiveness of the research, survey, and development work presently carried on by the various States, universities, and Forest Service, USDA. A significant amount of research would be carried out through contracts and cooperative agreements with States, universities, and research organizations. The proposed Spruce Budworms Program would build upon and extend the technology being developed in the ongoing USDA Douglas-fir Tussock Moth Program.

In April 1975, the Spruce Budworms Program proposal was presented to the Deputy Chief for Research, FS, for funding consideration when the opportunity arises.

Keith R. Shea, Moderator
Thomas McIntyre
Robert C. Thatcher
Kenneth H. Wright

USDA COMBINED FOREST PEST R&D PROGRAM-- ORGANIZATION STATUS AND PLANS

In 1973, three forest insects were causing major damage to the forest resources in the United States. In the West, the Douglas fir tussock moth was epidemic on over 800,000 acres. Across the South, from Texas to Virginia, the southern pine beetle was damaging or threatening over 74,000 square miles of susceptible pine forest types. In the Northeast, the gypsy moth had defoliated over 1.7 million acres of hardwood forests in rural and urban areas. Damage from these three insects alone was estimated at over $100 million. Methods for suppressing these outbreaks were either unavailable or only partially effective and of short-term value.

In August 1973, Mr. Robert W. Long, Assistant Secretary for Conservation, Research, and Education, U.S. Department of Agriculture, called upon four Federal agencies--Agricultural Research Service, Animal and Plant Health Inspection Service, Cooperative State Research Service, and Forest Service--to pool resources and develop a coordinated program to provide means for suppressing damage from these three pests within short time frames. Planning was completed by March 1974, reviewed within the Department and approved by the Office of Management and Budget. Testimony before the House and Senate Appropriations Committees resulted in a Budget Amendment signed by the President in August 1974. The research and development efforts were activated in FY 1975 by the Department of Agriculture as the Combined Forest Pest R&D Program.

COMBINED FOREST PEST R&D PROGRAM

The Combined Forest Pest R&D Program includes research and development programs for three forest insects--Douglas fir tussock moth, southern pine beetle, and gypsy moth.

Planning--Because of the complexity of the problems and the need to achieve specific objectives and accomplishments within definite time frames, new approaches for program planning were needed. Dr. Ned D. Bayley, Staff Assistant to Assistant Secretary Long, led the planning team from the four Federal agencies and several universities. A new program planning technique was developed--Adapted Convergence Technique for Agricultural Research (ACTAR).

ACTAR utilizes some of the general features of systems and network approaches, but avoids the requirements of certainty in achievement and rigidity of time scheduling. The program is developed sequentially on the basis of research logic and designed to meet specific objectives within given time frames.

Objectives--Each of the three insect programs is designed to (1) implement the available methods for reducing impacts of the insect, and (2) develop new short- and long-term technology needed to prevent or suppress economically damaging outbreaks.

Although the programs differ slightly in structure, three major areas of investigation are being pursued: (1) detecting, evaluating and predicting pest populations and their impacts on forest ecosystems; (2) techniques for suppression and regulation of pest populations; and (3) integrated pest management strategies.

The ultimate goal is to provide systems for managing each insect. An array of tactics and strategies which will alleviate or prevent damage and which are consistent with forest management objectives will be developed for use by forest managers and pest control specialists. More effective methods for making decisions to control the target insects also are anticipated. We anticipate spinoff technology will apply also to other related forest insects.

Funding--The Program was activated in FY 1975 with a Budget Amendment of $6.0 million. This, plus base funds available to the Federal agencies brought total funding in FY 1975 to $9.0 million--Gypsy Moth, $4.5 million; Southern Pine Beetle, $2.5 million; and Douglas Fir Tussock Moth, $2.0 million. Comparable funding is planned over a 4- to 5-year period and involves a projected total of $46.8 million to achieve the established objectives.

Organization and Administration--The Combined Forest Pest R&D Program is administered from the Office of the Secretary, U.S. Department of Agriculture. The Staff Officer, Dr. Keith R. Shea, provides staff support and coordinates activities among the three insect programs. Each program is directed by a Program Manager--Gypsy Moth, Mr. Thomas McIntyre; Southern Pine Beetle, Dr. Robert C. Thatcher; and Douglas Fir Tussock Moth, Mr. Kenneth H. Wright. All four report directly to the Chairman of the Program Board, Mr. Paul A. Vander Myde, Deputy Assistant Secretary for Conservation, Research, and Education.

The Program Manager is the principal line officer with full authority to manage the programs. He is assisted by a Research and an Applications Coordinator who are responsible for coordinating the research, information transfer, and developmental aspects of the R&D program.

A Program Board provides national overview, guidance and advice. The Program Managers prepare an Annual Plan of Work and Budget for review by the Board. At the review, accomplishments during the past year are assessed, progress toward objectives evaluated, and any needed Program adjustments recommended. The Annual Plan of Work and Budget recommended by the Program Board and approved by the Assistant Secretary for Conservation, Research, and Education, serves as the guiding document for each insect program.

The Program Manager is responsible for selecting and funding R&D activities which meet the requirements of the Annual Plan of Work and Budget. The Program Managers and their Research and Applications Coordinators continuously monitor progress on funded activities. When needed, specialized experts are used to evaluate highly technical problems. In addition to work conducted by the four Federal agencies, research and development activities currently are underway in 30 universities, colleges, and State Agricultural Experiment Stations, 9 State Forestry organizations, and a number of private industries.

Summaries of the current status of each insect program follow. I encourage you to contact the Program Managers for details.

DOUGLAS FIR TUSSOCK MOTH PROGRAM--Kenneth H. Wright

The Program objectives, organization and structure were described at the 1975 WFIWC meeting at Monterey, California. Accordingly, my presentation this year will be primarily to update you on happenings and accomplishments during the past year.

KEY EVENTS DURING THE YEAR

A chronology of key events during the year is as follows:

-- Fiscal Year 1975 extramural funding was placed in late winter and early spring. Approximately 100 scientists and graduate students received funding from the Program.

-- Eleven subject area Working Groups were formed and are working very effectively as coordinating mechanisms.

-- Applications Coordinator Jed Dewey joined the Program full-time in June to round out the headquarters staff.

-- Progress reports on all studies were submitted in mid-October and served as the basis for subsequent Working Group meetings to review progress, identify gaps in the Program and strengthen coordination.

-- Proposals for Fiscal Year 1976 funding were solicited, reviewed and are now being processed.

-- A published Progress Report on the first year's accomplishments will be released in spring 1976.

ACCOMPLISHMENTS

The Program is structured under five Phases; some accomplishments in each are as follows:

Phase 1--Population Dynamics

Information on epidemic populations is being used to develop a family of models that can simulate changes in population size and thereby predict impacts on trees and stands.

The synthesized pheromone of DFTM was used very successfully in 1975 at some 1,320 locations in 9 Western States to determine presence or absence of the insect. Moths were trapped at several locations where the insect was previously unknown.

Several thousand parasites and predators of DFTM were collected in 6 Western States and identified; progress was made toward determining their role in regulating population fluctuations.

Considerable genetic variation was found in DFTM populations across the West; this knowledge may be useful in identifying vigor strains of the insect.

Phase 2--Relationships of Outbreaks to Tree and Forest Conditions

Forest site and stand characteristics were identified that appear to influence location and severity of DFTM outbreaks.

Starch content of trees is affected by defoliation and appears promising as a predictor of tree condition, particularly in regard to their survival.

Good progress was made in developing pre-outbreak stand models for use in comparing timber and non-timber values of defoliated vs. non-defoliated stands.

Phase 3--Control Measures for Suppression and Regulation

As the result of field tests of chemical and microbial agents in 1975, primarily in British Columbia, there are now five materials that are highly promising for use as alternatives to DDT in controlling DFTM. They are the chemical insecticides Orthene, Dimilin, and Carbaryl, and the microbials Bacillus thuringiensis and a natural virus. Application has been made to EPA for registered use of the microbials (Note: Notification has since been received that the Thuricide formulation of B.t. has been registered).

Successful studies were conducted to improve aerial spray equipment and technology in regard to types of spray systems, aircraft guidance, controlled spray behavior, and spray deposit assessment.

Spray formulations were improved through laboratory, airport and field tests of materials such as stickers, spreaders, dyes, anti-evaporants, and sunscreens.

Phase IV--Socioeconomic Evaluation of DFTM Impacts

Much information was collected on impacts of defoliation on non-timber resources, such as understory plants, wildlife habitats, water quality and quantity, and recreation. This quantitative information will be converted into socioeconomic terms for use by the forest manager in decisionmaking.

Phase V--Development of Pest Management Systems

Procedures for synthesizing and integrating findings from all studies were established--and are being implemented to ensure sharp focus on the ultimate objective of the DFTM Program, which is to develop optimum pest management systems.

In conclusion, we feel the DFTM R&D Program is proceeding well. We are particularly encouraged with the excellent spirit of cooperation and teamwork being demonstrated by investigators from all sectors of the scientific community.

SOUTHERN PINE BEETLE PROGRAM--Robert C. Thatcher

The southern pine beetle has severely damaged pine resources in 10 Southern States in recent years. Recommended control approaches have neither prevented nor significantly reduced continuing losses. More effective preventive or remedial control approaches are urgently needed. An accelerated R&D program was organized, funded, and implemented in FY 1975.

ACCOMPLISHMENTS

The organization and management approaches for the Southern Pine Beetle Program were described in some detail. Highlights of accomplishments to date were summarized for several subject areas as follows:

Impact--Improved survey methods have been developed for documenting infestation location and associated tree and volume losses. Economic impact models have been constructed for timber and recreation resources. Progress has been made in determining the utilization potential of beetle-killed trees.

Insect sampling and population dynamics--Methods have been developed for sampling within-tree beetle populations in several States. Data handling procedures have been worked out. Developmental rates of beetle life stages are being determined. Processes affecting insect and host systems and their interactions are under study.

Mortality and competition factors--The roles and seasonal abundance of candidate parasites, predators and pathogens are being determined.

Site/tree/stand characteristics--Data is being accumulated on site/tree/stand conditions associated with infested and uninfested trees and/or stands over a broad geographic area. Information is being used to relate susceptibility to attack and frequency and intensity of infestations to specific soil, site, tree, and/or stand conditions or characteristics.

Behavioral chemicals--Several attractive fractions have been isolated and successfully bioassayed. Response has varied between sexes of the beetle, seasonally and among beetles from different geographic areas.

Toxicants--One and two percent chlorpyrifos formulations have been more effective in preventive and remedial control than 0.5 percent lindane. Residual properties are being determined.

Forest practices--Field studies of the cut-and-leave and cut-and-top approaches have resulted in stopping infestation spot growth and break-out in study plots in two States.

PLANS FOR CONTINUED WORK

Data will be acquired to verify economic impact models. Management guidelines will be developed for utilizing beetle-killed trees. Within-tree sampling will be extended to infestation spot and area population measurement and prediction. Critical mortality and competition factor information will be integrated into population dynamics models and life tables. Risk- or hazard-rated systems will be developed for forest stands in several areas of the Southeast. Formulation and use patterns for behavioral chemicals will be developed and evaluated. The efficacy of additional candidate toxicants will be determined. Preliminary tests will be conducted to determine the effect(s) of selected forest practices on incidence and severity of beetle-caused losses. Study results will be integrated into pest management approaches.

GYPSY MOTH PROGRAM--Thomas McIntyre

The gypsy moth is now well established as a major forest defoliator over much of the Northeastern United States. Outbreaks involving large acreages of urban and suburban environments have occurred periodically since the pest's accidental introduction near Boston, Massachusetts, in 1869. The current gypsy moth outbreak has been developing since 1968 and is expected to continue in some States through 1976, perhaps longer.

The basic planning document outlining the Expanded Gypsy Moth Program was completed in March 1974. Following approval of the plan, funds were appropriated later that summer, staffing of key positions followed, and funds to initiate the R&D effort were released early in 1975. A total operating budget of approximately $4.5 million annually was committed for FY 1975 to the Department's Expanded Gypsy Moth R&D Program. Staffing of the program includes a Program Manager and a Research and Applications Coordinator. Advisory assistance, consultation, and review is solicited from a special program committee and technical reviewers, primarily scientists from universities and State Experiment Stations.

The program is concerned with three broad research areas or activity phases. These include: (1) prediction of pest populations and impacts, (2) perfecting techniques and methods of managing populations, and (3) developing integrated control strategies for pest management systems. Progress toward achievement of program goals during the first full year of the program are noted below. Due to space limitations of workshop proceedings, only highlights of progress are reported herein.

ACCOMPLISHMENTS

Phase I--Predicting Pest Populations and Impacts: A major effort has been devoted to an analysis of historical data of 90 to 150 plots maintained from 1910-31. This information, to be published soon, permitted development of a model which simulates the interaction of the gypsy moth with the early New England forests.

Sampling techniques for several life stages of the insect are under intensive study. A regression method for estimating total egg masses was developed and suggests that a point sampling procedure will be more effective than fixed-size plots. Studies have also been completed on an atmospheric dispersion model that predicts small larvae do not disperse in the air for long distances--most larvae were recovered within 400 feet of the source area.

A series of studies on evaluation of impacts by the pest are in progress. These include: (1) collection and analysis of 5 years of data from chemically threated versus defoliated plots, (2) testing of a photometric interpretation technique to estimate defoliation from photographic

measurements, (3) study of root starch content as an indicator of vigor and predictor of tree condition, and (4) development of forest simulator to assess the effects of defoliation on growth and yields of trees and stands.

Phase II--Managing Gypsy Moth Populations: Laboratory and field investigations have been conducted in the following areas:

Parasites and predators--Essentially completed studies on two of the most efficacious parasitoids. Initiated foreign parasite exploration and collections in Japan and increased similar efforts in France, Austria, and Poland.

Virus--Obtained nearly all safety and efficacy data required for registration. A few studies with a technical product rather than a highly purified virus are still in progress. Additional investigation with less expensive formulations will hopefully result in development of a more economical treatment. Field trials were initiated to test the potential of vectoring the virus into the host population with parasitoids.

Pheromone--Emphasis was directed at evaluating traps for detection and monitoring, study of improved pheromone dispensing systems for traps, and aerial dispersal in mating inhibition studies. Environmental monitoring was begun to accumulate data required for registration. Behavioral research was continued to secure information on adult long- and short-range communication systems. Chemists have produced and laboratory evaluated four new formulations for 1976 trials.

Insecticides--Dimilin, an insect growth regulator, was pilot tested. Excellent population reduction was obtained using .06 pounds/AI/acre. Monitoring studies evaluating nontarget effects were completed providing sufficient data to complete a registration application which was submitted to EPA in February 1976.

Mass rearing--Tremendous numbers of all gypsy moth life stages are required for laboratory and field research involving insecticides, the virus, and pheromone. To improve rearing technology, a special team is involved with study of (1) cheaper and less complex synthetic diets, (2) determining optimal environmental regimes for development, and (3) automation of rearing procedures to reduce production costs.

Phase III--Developing Integrated Control Strategies for Pest Management Systems: At this time, significant improvement in gypsy moth control strategy will depend upon developing more effective current-year population and potential impact assessment; availability of improved control measures (such as chemical pesticides); defining "trigger points" at which the selection of control measures should change.

There is still too much unexplained variation in gypsy moth population trends from place to place and time to time to permit the development of coordinated multi-place, multi-year control strategies. In most cases, there seems to be little to be gained from relatively elaborate variable-dose-rate strategies or from successive applications of the same treatment, or from joint or successive application on different control agents.

SPRUCE BUDWORMS: POPULATION DYNAMICS AND MODELLING

Moderator: Dave Leonard

Participants: Gary Simmons, Scott Overton, Roy Shephard, as well as many of the 35 in attendance, particularly Gordy Howse, Bill Waters, Alan Berryman, John McLean, Bob Heller, and Walt Cole.

The Holling Model was introduced in the morning session by Gary Simmons. It was developed for "eastern" spruce budworm, Choristoneura fumiferana, with 265 site models covering most of the spruce-fir type in the Province of New Brunswick. Much of the workshop discussion concerned the possibility of the Holling Model as a framework for a similar model of western budworm, Choristoneura occidentalis. There are some difficulties. The validation of the eastern budworm model can be checked by the use of historical data, but these are lacking for western budworm.

Although inventory data may be more complete in the West, there are fewer data on the biology and ecology of western budworm. Important considerations for western budworm would include site characteristics, elevation, moth and larval dispersal, and larval feeding behavior.

The driving force of the eastern budworm is a foliage-area relationship. The eastern spruce-fir forests are essentially contiguous. The foliage-area relationship may be a less suitable parameter for western budworm because of the increased spatial separation of trees and stands in western forests.

The impact of the eastern budworm on mature stands of spruce and fir is well documented, and where outbreaks run their course, considerable mortality occurs, particularly in the balsam fir component. The impact of western budworm on Douglas fir, true firs, and spruces, in terms of mortality, appears to be less. Site quality and stand density appear to be more important factors associated with tree mortality in western budworm.

In certain eastern areas, such as in the Adirondacks, outbreaks are less severe, and a site model should be developed in such areas to determine the critical inputs. Frequently, such areas are associated with more mixed forest type, and greater budworm parasitism.

Moth dispersal behavior and dispersal patterns of eastern budworm are becoming well documented, particularly with the recent research findings of Dave Greenbank. In the western budworm situation, the montane terrain would affect wind fields and dispersal patterns. Sparseness of suitable hosts could affect

ovipositional success of immigrant moths. Temperatures at higher elevations could be critical if below the threshold for flight activity.

There are considerable life-table data on eastern budworm, generated mostly from the Green River Project. In the population dynamics model, predation of larvae during low budworm population densities is a critical element in the simulation of outbreaks that correspond closely with historical data. Much fewer life-table data exist for western budworm, and such would have to be collected during the construction of a model.

Because the altitudinal variation would affect the phenology of the hosts, and budworm development and dispersal, the site models for western budworm might have to be based on phenological or elevation bands, rather than the system for eastern budworm where differences in relief are small.

Scott Overton noted several important considerations of models. Models are designed for a specific purpose, and most criticism of them comes from those who try to adopt a model to a purpose for which it was not designated. Each model should fulfill certain criteria, and to do this it is not always necessary for the model to be numerically precise. Precise prediction is not always achievable over a short time-frame. Models provide an understanding of the nature of the system, and provide a general strategy of management or tactics for management. The budworm model is not a predictive model, but is a descriptive one, and descriptive models are not intended to be extrapolative. The model is, furthermore, only applicable to the site it was designed for.

The usefulness of the eastern model in determining research priorities and alternative control strategies was discussed. The model does a good job of qualitatively capturing what one would expect to happen in New Brunswick. Through the modelling process several research priorities were established. Among them were to gather more information on stand dynamics and impact and on the role of vertebrate predators in preventing a population explosion. Some of the original modelers who assisted in putting together the model are now in the process of adapting the model to the State of Maine.

DEFOLIATOR PHEROMONES - CHEMISTRY AND APPLICATIONS

Moderator: Gary Daterman

Insects discussed included eastern and western spruce budworms, gypsy moth, Douglas-fir tussock moth, and spear-marked black moth. Iain Weatherston, Jim Richerson, Skeeter Werner, and Gary Daterman led discussions on their respective "pet" insects. Pertinent facts are given below in individual summaries. The tussock moth, gypsy moth, and budworm discussions provided a basis for comparing progress and problems for major eastern and western species. The spear-marked black moth was of special interest because little information has been available on pheromones of the Geometridae.

EASTERN SPRUCE BUDWORM AND OTHER Choristoneura (Iain Weatherston)

In 1971, trans-11-tetradecenal was identified as the sex pheromone of the eastern spruce budworm Choristoneura fumiferana, and as being an important component of the western spruce budworm (C. occidentalis) attractant. In subsequent years, inconsistent trapping results with commercial preparations of trans-11-tetradecenal led to further investigations. These studies were carried out by analyzing various commercial preparations while reconsidering the natural material from the female budworm. Diversity of chemical structure is a factor in maintaining species integrity, and variation in pheromone structure may be realized through differences in functional group, chain length, positional isomerism, geometrical isomerism and the formation of "blends" of two or more compounds. In the case of C. fumiferana, the original work ruled out such possibilities with the exception of positional and geometrical isomerism. Considering the synthetic materials, and the route of their synthesis via the unsaturated 14-carbon alcohol, this compound could have been responsible for the inconsistent trapping data since it is a known inhibitor. This was discounted when no tetradecenols were found in the synthetic samples. After unsuccessful attempts to separate the tetradecenal isomers using gas chromatography with packed columns, the separations were achieved gas chromatographically using 50' SCOT capillary columns with either DEGS or PDEAS as the liquid phase. Utilizing this technique the natural pheromone obtained from female C. fumiferana was shown to contain 96.1% trans and 3.9% cis isomers of Δ-11-tetradecenal.

Field trials in which various combinations of isomers were dispensed in separate polyethylene stoppers (magicaps) indicated that trans-11-tetradecenal containing as little as 1% of the cis isomer trapped more than 10X the number of moths caught by the pure trans isomer. The most attractive of all the cis/trans mixtures tested was that of 98% trans and 2% cis which showed a 30X improvement over the single isomer, and was 3X better than a

female budworm. (Field tests carried out by C. J. Sanders, G.L.F.R.C., Sault Ste. Marie).

The sex pheromones of tortricine species are generally 14-carbon monounsaturated compounds having the double bond in the Δ-11-position. In 1975, six compounds, the cis and trans isomers of 11-tetradecenal (TDAL), 11-tetradecenol (TDOL) and 11-tetradecenyl acetate (TDAC) were tested as attractants for the large aspen tortrix C. conflictana. The compounds were dispensed in magicaps at a loading of 100 ug/cap. During the period June 25 to July 3 traps baited with cis TDAL caught a total of 69 C. conflictana males. Traps baited with the other five test compounds failed to catch any aspen tortrix. To identify compounds having a synergistic or inhibitory effect on cis TDAL, various mixtures of cis TDAL/cis TDOL, cis TDAL/cis TDAC and cis TDAL/trans TDAL were also tested. The results indicated that cis TDAC is inhibitory in all proportions, cis TDOL is inhibitory if it is the major component of the blend. It is unclear whether small amounts of cis TDOL function as a modifying component. The results of the cis/trans TDAL mixtures exhibited a trend of antagonism with the presence of the trans isomer.

The oblique banded leafroller, C. rosaceana was caught in traps baited with cis TDAC, the published pheromone structure of this species. However, an 8X increase in the catch was recorded in traps baited with a cis TDAC/cis TDAL (100/1) mixture. The results of these studies with various tortricine species emphasize the paramount importance of trace components in pheromone blends.

WESTERN SPRUCE BUDWORM (Gary Daterman)

The western spruce budworm, C. occidentalis, shares with the eastern spruce budworm, C. fumiferana, its major pheromone chemical, trans-11-tetradecenal. Unlike the eastern budworm, however, it is unclear as to the need for the opposite (cis)isomer. In cooperation with Weatherston, Sanders, and Shepherd of the Canadian Forestry Service, work is continuing on this problem.

The major effort for field application of the western budworm pheromone has been in trapping to evaluate population densities. The objective is to assist in predicting damage for particular areas. This effort has been underway since the 1973 season and appears promising. The correlation between numbers of trapped males versus the following season's defoliation estimates on the same plots have been encouraging.

There are a number of questions and technical problems associated with this approach. For instance, a major assumption is that trapped males reflect an equivalent number of females laying eggs in the same area; however, some of the females could be migrating in or out of the area

independent of the male population. A major problem is to design a trap capable of capturing the range of populations available in the various areas. Usually, the traps tend to fill up too soon thus losing their ability to reflect the higher population levels. Another problem is inter-specific attraction since ten different species were captured in Oregon and Washington study plots.

A minor effort involves a less-damaging western species, C. viridis (Modoc spruce budworm). In cooperation with the Canadian workers, the major pheromone constituent of this species was identified as trans-11-tetradecenyl acetate. Secondary chemicals undoubtedly exist, but have yet to be identified. No effort is underway to develop this pheromone for field application. This pheromone was attractive to 14 species representing seven different families when tested in Washington, Oregon, and northern California.

SPEAR-MARKED BLACK MOTH, Rheumaptera hastata (Skeeter Werner)

The spear-marked black moth, a geometrid defoliator of birch in Alaska, reached epidemic population levels from 1974 and 1975 and infested 2.6 million acres. A lack of information on this insect prompted an investigation on its biology and behavior. One study was conducted to determine if a sex pheromone was produced.

Laboratory observations of adults showed that females assumed a calling position one day after emergence and a positive response was elicited from males. This indicated a pheromone was probably produced by females and a laboratory bioassay was set up to test this hypothesis. A simple olfactometer was used in which bottled "purified" air was passed through a rotometer and into an Erlenmyer flask which contained live calling females; then via tygon tubing into a flask containing virgin males. A positive response was recorded when male moths exhibited rapid movements about the test chambers with wing fluttering, antennal waving, and extension of the abdomen with clasper display. Ether extracts of the terminal abdominal segments were placed on filter paper and bioassayed in terms of female equivalents. Both types of bioassays used virgin males and females of various ages. The results showed that females started to produce pheromone when two-days-old and continued for 9 days with maximum male response to 3-day-old females. Only males 3 to 10 days old responded with maximum response from 5-day-old males. Field tests were conducted in which live females and extracts were placed in cardboard traps coated with Tanglefoot®. Field bioassays confirmed the production of sex pheromone but male response to extracts was lower than in lab bioassays. The reduced response was probably due to the high rate of volatilization of extract from the filter paper.

Examination of the internal reproductive system of females revealed a pair of organs not commonly found in Lepidoptera. These paired glands extended from the 7th abdominal segment into the 10th segment where they joined and had a common opening between the papillae anales. Histological examination showed the glands were composed of glandular epithelial cells with the epicuticle enlarged into a continuous lumen on the internal area of the glands. Bioassay of the gland, the other internal tissue excluding the gland, and the external integument indicated the gland was highly attractive to 5-day-old males. A similar gland was described by Urbahn (1913) in his paper on abdominal scent organs of Lepidoptera.

GYPSY MOTH (Jim Richerson)

The goal in the pheromone component of the gypsy moth program is to maximize the action of disparlure - whatever that action may be. Current efforts are concentrating on the air-permeation approach to pheromone mediated control. The problems encountered can be expected in any new field of research where the fundamental concepts and accompanying technologies are rapidly evolving.

The synthetic gypsy moth pheromone, disparlure, must contain ca 85% cis isomer according to USDA specifications. The actual amount of cis:trans isomers varied somewhat from year to year. There is no evidence for an optimal blend of geometric isomers in the pheromone system of gypsy moth. A Japanese group in 1975 reported that the pure enantiomer of disparlure is 10X more active than the racemic mixture of the US formulation. Research is underway to synthesize pure enantiomers (Michigan State Univ.) and the Japanese will supply a small sample of their enantiomers for research purposes. The olefin precursor of disparlure has not shown to be any better at disrupting male activity than disparlure. Little or no work is currently being done with the precursor. APHIS personnel are attempting to collect pheromone from lab reared females to determine the geometric and optical isomer characteristics of the natural pheromone. To date insufficient material has been collected to make any analysis.

There continue to be problems in application technology. The past formulations: paper chips, cork granules, microsieves, etc. as well as mass trapping efforts are not being pursued. The 2% microencapsulated disparlure formulation has been viewed as the most promising formulation for air-permeation since 1973. In 1975, field tests of this formulation did not perform well. The cause of failure of the formulation has not been determined. It is believed that the microencapsulated disparlure deteriorated due to adverse environmental factors. Presumably, any failure to achieve maximum disruption is due to the physical and chemical breakdown of the formulation. Research efforts into formulations are concentrating on the "behavior"

of the microcapsules in the forest ecosystem and in lab studies. In 1976, 3 additional formulations will be tested in the field: (1) 20% disparlure in more uniform sized microcapsules (<100μ), (2) a waxy matrix wettable powder, and (3) Conrel® fibers. All of these will be tested in the air-permeation=(confusion) concept.

Traps designed for survey, detection, and to monitor mating disruption are being investigated to determine the limits of their efficiency. Previous efficiency measurements relied on catch numbers alone. Richerson and Mastro (Penn. State Univ.) demonstrated that the conventional designs used for all 3 purposes were very inefficient in capturing the males attracted. A more reliable measure of trap efficiency is the ratio of the number of males orienting to the trap per unit time and the number of males caught per unit time. All of the various bait dispensers when exposed on trees attracted males and elicited copulatory activity. None were as attractive as virgin females. In 1975, Hercon wicks baited with 6 mg of lure were nearly as attractive as females. In 1976 traps, both Hercon wicks and Conrel fibers will be tested as dispensers. Behavioral data from Richerson on the sexual activity of the gypsy moth indicates that while the natural or synthetic pheromone is required to maintain sexual activity, a wide variety of stimuli can be used by the male to locate females within 15 cm of a female. Gypsy moth adults appear to have a flexible behavior making total disruption of mating difficult. However, the full potential of disparlure to disrupt mating, to detect infestations and for other purposes has not been fully explored.

DOUGLAS-FIR TUSSOCK MOTH (Gary Daterman)

The major constituent of the Douglas-fir tussock moth, Orgyia pseudotsugata, pheromone has been identified as (Z)-6-heneicosen-11-one. Work is continuing on identification, since we strongly suspect the existence of secondary compound(s). The single identified compound, however, has been shown to be extremely potent in field trials and work is moving ahead on applications in survey and control work.

In 1975, several thousand traps were distributed throughout the western states for detection purposes. Douglas-fir tussock moths, with very few exceptions, were captured in almost every area trapped. Many of these areas included locations thought to be free of the insect. The pheromone was also attractive to several other western lymantriid species including the western tussock moth, O. vetusta, the rusty tussock moth, O. antiqua, and Parorgyia grisea. The major thrust of the tussock moth pheromone effort is toward development of pheromone-traps capable of evaluating population-density and assisting in damage prediction. This is

of special importance with tussock moth, because this species is capable of exploding to damaging population levels within a very short time. Hopefully, pheromone traps can assist in detecting these kinds of populations releases one-two years prior to the occurrence of actual damaging levels.

An effort to evaluate tussock moth pheromone for control purposes is also underway. A preliminary test in 1975 involved one hectare plots wherein releasers emitted synthetic pheromone at the rates of .05, .5, and 5.0 mg/hectare/day. Based on pheromone captures in traps baited with live-female baits within and outside these treated areas, the treatments were very effective in disruption of normal reproductive behavior. These tests will be expanded in 1976 to obtain better dosage response information, and to better evaluate the feasibility of the approach for this insect.

WORKSHOP: CHEMICAL TESTING AGAINST DEFOLIATORS
Moderator: Robert L. Lyon
Speakers: Wayne Bousfield, Bill Ciesla, John Hazard, Chandra Nigam, A. P. Randall, Pat Shea.

The workshop was attended by over 40 participants. The speakers gave brief talks to open up the subject matter and stimulate discussion. Emphasis was placed on three aspects of the broad subject of chemical testing against defoliators:

1. Experimental design of field experiments and pilot projects. (The term "field test" will be used in this summary when jointly referring to both field experiments and pilot projects.)

2. Laboratory screening and bioassay specifically aimed at providing data needed to select candidates and treatment variables for field tests.

3. The research and development process--its appropriate content, sequence of activities, coordination, etc., from preliminary laboratory testing to final pilot projects preceding recommendations for operational use and registration.

The accomplishments of the workshop are summarized in the form of some of the major questions participants felt were important, followed by a synopsis of the ensuing discussions.

Experimental Design

Why aren't operational projects getting the same level of control experienced in field tests? A related question: Why don't insecticides work in the field after registration?

In order to expect the same performance in operational control programs as was achieved in field tests, the same scope of environmental and ecological variables encountered in the operation must be encompassed and sampled in the field test. There needs to be a coordination between the sampled population and the population that represents the scope of the pest problem. If the pest problem is a regional or multiregional one and the field test is confined to a drainage, one would not be sampling all relevant experimental conditions. Results may not be applicable to conditions outside the sampling area.

Often we may be dealing with "waning" populations in field tests or with populations in descending stages of an outbreak when disease and other factors could affect the insects' susceptibility

to chemical stress. Insect populations in the ascending stages of an outbreak maybe more vigorous and it may take a higher dose to kill these in an operational control program than the dosage estimated to be satisfactory in field tests conducted on the tail of an epidemic. This point was controversial. There was considerable disagreement as to the degree to which entomologists are aware of this problem and how common and serious a problem it actually is.

Testing precision may be relaxed from field experiment to pilot project to control operation. Field experiments are characteristically designed around precise specifications as to meteorological conditions, chemical formulation, spray application, sampling procedure, etc. Standards are more relaxed in pilot projects and further in an operation which places an additional burden on the performance of a formulation, especially when aiming for control with a minimum of active ingredient and a minimum of environmental disruption.

Why are field tests often inconclusive or results often not reproducible?

There may not have been sufficient planning to anticipate what could go wrong and to understand how such problems would affect interpretation of results. Criteria should be set in the planning stages on such matters as what constitutes an acceptable or adequate deposit or spray coverage, appropriate check plots, acceptable populations (both in quality and quantity), acceptable meteorological conditions, spray application equipment and procedures, etc. It may actually be more appropriate and economical to cancel a test if certain critical parameters do not meet specifications rather than conduct the test and produce yet more inconclusive data.

Reproducible results require that specifications between tests be coordinated, i.e., equipment, formulations, droplet spectrum, etc. Some of the points made in regard to the question above also apply here.

What are the differences between field experiments and pilot projects?

The purpose of the field experiment is to compare the performance of various treatments. It may take on many forms (discussed later) and is designed to generate new knowledge through systematic repetitive measurements. The objective of a pilot project (In Canada these are called semi-operational tests.) is to estimate whether performance is good enough to warrant registration and operational use. It is an evaluation of the operational feasibility of a method shown by research to be highly promising.

Pilot projects are generally limited to one treatment combination; field experiments can encompass several. Pilot projects are conducted on larger acreages than field experiments to simulate the magnitude of operational conditions. Application systems often differ. Small helicopters are normally used in field experiments; larger helicopters and fixed wing aircraft are used on pilot projects. In both tests, evaluation of effects on non-target organisms may be conducted, though the large acreages used in pilot projects provide opportunities for unique operational evaluation not available on small experimental plots.

Laboratory Screening and Bioassay

What kinds of laboratory bioassays are currently conducted to provide guidelines for selecting chemicals, formulations and other test variables for field testing?

Similar tests are conducted in Canada (mainly Chemical Control Research Institute (CCRI), Ottawa) and the United States (mainly PSW, Berkeley). These consist of contact toxicity bioassays on larvae in a spray chamber, and feeding and residual bioassays on potted trees also treated in a spray chamber. Weathering of the treated trees outdoors permits estimates to be made on the length of effective biological activity.

Residual tests on potted trees by CCRI have received considerable emphasis providing extensive data on many insect species and formulations on several conifer species. A given treatment is evaluated in three separate years, generally with field collected insects, and is conducted at the time the larvae are active normally in the field.

At PSW additional tests are conducted on rainfastness in which potted trees are subjected to simulated rainfall to evaluate the influence on biological effectiveness of test formulations. Research at PSW includes studies on phloem mobile systemics as well.

Are bioassays prerequisite to field tests?

Yes. Bioassays provide the necessary toxicity data to make qualified judgements about the most promising candidate materials and formulations and provide guidelines for selecting rational dosage levels and other variables in field tests.

The Process of Research and Development

What is the appropriate sequence of activities in the R & D process?

An idealized sequence might be as follows: laboratory bioassays, individual tree field tests with ground application equipment, small aerial field experiments, larger aerial field experiments, pilot projects (or semi-operational tests) repeated as necessary. Actual testing procedure varies from this. In Canada, after laboratory bioassay, selected materials are generally tested on individual trees and in plantations using ground equipment, thence to aerial field tests from 100's of acres to 10's of thousands of acres depending on the purpose of the testing, e.g., for safety; for regional testing purposes, etc. In the United States, individual tree tests are not generally conducted before aerial tests. Field experiments are generally done on 20-300 acre plots and pilot tests on 1000-3000 acre blocks. Another variation are the so-called "field bioassays" where treated foliage in the field is brought to the laboratory for bioassay with reared insects in cases where wild populations are not available or for other reasons. This method has some limited usefulness. Field bioassays would not be useful for testing highly labile, short-lived materials such as some ephemeral pyrethroids, since there is likely to be no residual action. They would be more useful when the residual toxicity is the major component in mode of action. In the United States, as the R & D effort proceeds from the laboratory to the various field tests, there is a gradual shift in leadership and involvement by FIDR to FIDM.

What are the alternative courses of action following completion of a pilot test?

Either the formulation is proven ready for operational use and registration is recommended, or further field experiments or pilot tests are indicated, or the formulation is rejected because of some insurmountable operational problem.

Do pilot tests establish new control methods for pest management?

There is some question as to whether pilot tests as now constituted can provide enough data to justify going full scale operational. A case in point: the minimum acreage that would have to be treated to fully test a given control strategy may be much larger than the acreage now generally treated in a pilot project in the U.S. This may speak for setting up test units that conform to natural "ecological" or "entomological" units.

Should the Agricultural Chemical Industry be involved in the R & D process?

Yes! Close liaison should be maintained with the producers of the materials being tested. This is very critical. They have access to considerable information about their products and should be

involved more in the planning stages to take advantage of the best judgement about formulation, dosage and other matters. The company is the registrant and we should be continually together on this process.

What does EPA require for the registration of chemicals for forest insect suppression?

The naiveté and confusion of the participants were clearly evident. Nothing substantive emerged from our discussions. It does appear that what is required is still evolving and that the more data we provide, the more we may have to provide in the future. EPA is under pressure by many groups including environmentally oriented enthusiasts which probably operates to increase pressure for expanding data requirements.

This summary can only provide a partial feeling for the substance of the workshop. A number of questions were raised but only superficially discussed or not at all. Still others seem important to raise. These are listed below in hopes that they might be useful in developing the content of future workshops on the subject of chemical testing.

1. What criteria should be used to judge the outcome of field tests?

2. Should Abbott's formula be used to "correct" the treatment effect?

3. What are the most important treatment variables in field experiments? Should they be prioritized and/or affected by available reserves and urgency for registration?

4. What are appropriate plot sizes and number of replicates? What is the minimum plot size for aerial field experiments?

5. Should formulations be field tested when still "experimental" (before any uses have been registered)?

6. Can laboratory data be extrapolated to field conditions? How can this be improved?

7. Must laboratory bioassays always precede field tests?

8. Should field experiments be skipped under certain circumstances? What are the circumstances?

9. At what stage in R & D should field experiments be recommended? Pilot projects? What data are needed?

10. What is the appropriate sequence of environmental safety testing vs. efficacy testing?

11. Why does the R & D process in the development of chemical suppression methods seem so slow?

12. How can we improve on liaison with EPA to accelerate the registration process and the efficiency of generating appropriate data?

13. What guidelines can be used to decide which data the Forest Service should collect for registration and which the insecticide producers should be responsible for collecting?

POTENTIAL AND PROBLEMS ASSOCIATED WITH BIOLOGICAL CONTROL OF DEFOLIATORS

Moderator: Dick Schmitz

Nineteen participants attended the workshop: Copper, Furniss, Gravelle, Holt, Hamel, Hostetler, Hunt, Jorgersen, Joseph, McGregor, Mitchell, Ryan, Stelzer, Thompson, Trostle, Tunnock, Voegtlin, Wiggins.

Because it had been at least 4 years since conference participants discussed biological control of defoliators, participants chose to devote the allotted time to discussion of: (1) status of current biological control efforts directed against defoliators and (2) the possibilities and problems common to each defoliator discussed. Consideration of behavioral chemicals and microbials were excluded from the discussions because workshops dealing with these agents were scheduled later in the program. Discussion of the potential and problems of biological control of forest defoliators ultimately concentrated on the western spruce budworm Choristoneura occidentalis and the larch casebearer Coleophora laricella. The ideas and conclusions reached have been reorganized as presented here to enhance the continuity and clarity of the proceedings.

Participants felt the predator parasite complex of the western spruce budworm has been determined and except for a few instances does not appear to be a major source of mortality, particularly at high population densities of the host. Therefore methods for suppressing western spruce budworm outbreaks have relied on use of insecticides rather than biological agents. There is need to determine how best to conserve beneficial parasites where insecticides are used. Accordingly, most pilot tests of candidate materials now include evaluation of the effect of the insecticide on these agents. Dennis Hamel and Mark McGregor described the results of such an evaluation conducted during 1968 to determine the rate of parasitism by Apanteles and Glypta on western spruce budworm after application of Zectran. The evaluation was part of a cooperative pilot test of Zectran by the Insecticide Evaluation Project, Berkeley, California and USFS, Region 1, Missoula in two drainages near Missoula, Montana.

Zectran, a carbamate insecticide, was applied at 28.3 g (1 ounce; 6% by volume) in 0.47 liter (1 pint) of Dowanal, at a droplet size of 120 microns, per acre. Rate of parasitism was determined from live budworm larvae selected from 4 (15-inch-long) branches per tree, cut from mid crown of 40 trees for the prespray and 16

branches per tree from these 40 trees in the postspray. Larvae were reared on artificial media to determine percent parasitism by species. Sampling continued during 1969-1970 to determine the incidence of parasitism 1 and 2 years after spraying. Results are tabulated below:

Year	Belmont Creek		Chamberlain Creek	
	Apanteles	Glypta	Apanteles	Glypta
	% Parasitism			
1968 Prespray	5.5	11.8	3.2	7.5
Postspray	6.6	14.3	6.2	14.1
1969	6.6	10.3	6.3	11.8
1970	7.3	5.3	8.9	6.7

Budworm populations declined following spraying in 1968 and in 1970 no aerially visible defoliation was noted.

The results prompted considerable discussion regarding timing of insecticide application and sampling and rearing techniques as they relate to parasite survival. Workshop participants encouraged those responsible for planning pilot tests of insecticides to continue to evaluate effects of test chemicals on beneficial insects as a step toward developing selective treatments that reduce target insect but maintain favorable ratios of natural enemies.

A question was raised regarding biological control of the black headed budworm Acleris variana. Torgie Torgerson described his evaluation of its parasite complex noting that work had been completed but no effort had been made to manipulate populations for control purposes.

Status of the biological control program for larch casebearer, a lepidopterous needle miner native to Europe, was described by Roger Ryan and Dick Schmitz. The insect was discovered near St. Maries, Idaho in 1957 and now infests most western larch stands in Idaho, western Montana, and increasing portions of the larch type in Washington, Oregon, and British Columbia. Assessment of the impact on tree growth resulting from various levels of defolia-

tion is underway. Earlier examination of two sites in northern Idaho indicated that severe defoliation of 5 years duration severely reduced radial growth and contributed to stand deterioration.

Although the larch casebearer was discovered in Idaho in 1957, it was first reported in North America in Massachusetts in 1886 and subsequently caused severe defoliation on tamarack, Larix laricina, in eastern United States and Canada. Native parasites failed to achieve an acceptable level of control, consequently parasites of the casebearer were sought in Europe and five species were introduced during 1931 and 1934-39. All were eventually recovered, but two species, a braconid Agathis pumila (Ratzburg) and an eulophid Chrysocharis laricinellae (Ratzburg) predominated and are credited with being the most effective species released. By the 1950's casebearer populations had declined to the point that damage to tamarack was no longer considered serious.

The apparent success of exotic parasites in suppressing the casebearer in eastern North America spurred similar attempts in the west. During 1960-1969 an estimated 1,317,000 A. pumila were released at many locations in western Montana, northern Idaho, and northeastern Washington. Parasites were obtained for the most part from field collections in Idaho and Montana. Some were released as adults but the majority were obtained by transferring parasitized overwintered larvae to the new release site.

To data A. pumila has been released on 380 sites in Idaho, Montana, Oregon, Washington, and British Columbia. It has been recovered on 95 of 180 sites sampled thus far. Parasitism ranged from less than 1% to 85%. Present data are insufficient to categorize its rate of dispersal.

In 1972 additional species of exotic parasites were released in Oregon, Washington, Idaho, and Montana. In 1974 the casebearer research program was expanded and five species of parasites were released in Idaho on a range of sites representative of the infested area to compare rate of establishment and spread. Parent stock of these parasites were obtained through the CIBC and cooperators in Japan, and reared to sufficient numbers for release by Roger Ryan at the Forestry Sciences Lab, Corvallis, Oregon.

The most immediate problem involves sampling the 200 A. pumila release sites that have yet to be evaluated, to determine the presence of the parasite and determine its effectiveness. There is also need to correlate presence or absence of the parasite with release site environments to determine whether site conditions or other factors are responsible for successful establishment. More efficient sampling systems are essential to completion of this aspect of the evaluation.

Until introduced parasite populations other than A. pumila reach sufficient densities in the field so that adequate numbers can be reared from field collections, the number available for release will be restricted by availability of parent stock from foreign sources, limited capacity of existing rearing facilities, and the need to develop laboratory rearing procedures for each species.

Considerable discussion developed regarding the methodology needed to assess effectiveness of established parasites in light of limited manpower. Participants shared one of two viewpoints: (1) effectiveness should be documented soon after parasite establishment by use of life tables or (2) evaluation of their controlling effects should be determined by comparing casebearer densities in the presence or absence of parasites before and after parasite establishment. It was also suggested that high percent parasitism at low casebearer densities would also serve to substantiate the conclusion that a particular parasite is highly efficient.

Workshop participants reaffirmed the need to make more effective use of biological control agents in suppressing forest defoliators. Present inability to utilize or manipulate these agents to advantage results from our lack of understanding of these systems and the knowledge needed can only be gained from long-term studies. Until those responsible for setting research priorities and funding are willing and able to make long-term commitments to this research, biological control will continue to be a minor component of suppression strategies.

WORKSHOP: CURRENT APPROACHES TO CONTINUING PEST PROBLEMS
Moderator: L.H. McMullen

About 25 people participated in the workshop. The summary covers the discussions of several people who had previously been asked to participate.

Thom Dodd, University of Idaho, discussed the western pine shoot borer, Eucosma sonomana. It is a native moth causing reduced height growth on ponderosa, lodgepole, and plantation Jeffrey pines. Characteristic signs of attack become readily apparent once annual height growth is completed. Terminal shoots are stunted with shortened and closely spaced needles giving a "shaving brush" appearance. Upon dissection, the pith region can be found to be mined and contains packed frass and resin.

The adult flies in the spring about the time of host bud burst and shoot elongation. The eggs are believed to be laid at the base of the terminal bud. First instar larvae bore into the pith and mine solitarily. In early to mid-summer fifth instar larvae bore out of the shoot, leaving a characteristic oval emergence hole; over-wintering occurs in the duff in the pupal stage.

Substantial volume loss can occur on a repeatedly attacked individual. Heavily infested stands can show a 25% volume loss over the rotation. Stand susceptibility is related to site and is under further investigation. Reference to Karel Stoszek's earlier work can be found in Jour. of Forestry 71: 653.

Molly W. Stock, Washington State University, discussed a method for observing genetic constitution of Douglas-fir tussock moth populations. While we traditionally look at various external factors in the environment (e.g. climate, food type) in attempting to understand changes in population numbers, we also know that the individuals within a population vary from each other and that the response of the population to external factors depends, to a significant extent, upon the kinds and amounts of different types of individuals within the population. Variations in fitness and consequent "success" are expressed in forest pest insect species as population increases that are of concern to forest entomologists.

Although genetic mechanisms have been postulated to account for population changes, only recently has the methodology been developed to accurately observe the genetic makeup of populations. Traditional methods of inferring genotype from phenotype have many fundamental drawbacks. For example, a great many important characters of the population are recessive and not observable in heterozygous individuals. These recessive characters are of real concern

when attempts are being made to predict population behavior in future generations.

We can now examine intrinsic genetic variation by observing differences in the electrophoretic mobility of the protein products of different alleles of a given gene. Using techniques of starch gel electrophoresis we are looking at isozymes (isomers of enzymes) produced by selected genes in the Douglas-fir tussock moth. We have found large differences in genetic constitution both within and between populations. We are now seeking to discover if certain genotypes can be associated with release, outbreak, and decline phases of the population cycle and to determine the genetic relationships and distances between Douglas-fir tussock moth populations in western North America.

James D. Hansen, Washington State University, discussed the use of radiography in species determination of parasites of larch casebearer. Spilochalcis albifrons is a general pupal parasite which attacks a wide variety of hosts (4 orders and 27 families, including other parasites). Field collections indicate adaptability to many different habitats. It is the major parasite of the larch casebearer (Coleophora laricella), an exotic forest pest, except in areas of high Douglas-fir tussock moth (Hemerocampa pseudotsugata McDunnough; Lepidoptera: Liparidae) infestations. High S. albifrons parasitism does not interfere with present larch casebearer bio-control programs and denotes the lack of efficient larval parasites. Radiography has been used successfully to determine pupal stages of important larch casebearer parasites. Examples of radiographic prints were shown to the audience.

The moderator read a resume prepared by Rod Carrow concerning the approach to the balsam woolly aphid problem in British Columbia. Within the infested zone the aphid is generally distributed in Abies crowns. With such crown attack the damage is not severe and the impact can be tolerated. However, in mature-overmature stands (100+ years) stem attack appears sporadically, usually in small areas (< 10 acres), and usually results in tree mortality of stem-attacked trees. The objective of the research program within the next few years is to develop a hazard rating system, specifically directed to characterizing stands within the infested zone susceptible to stem attack. Specific goals are:

1) Characterize areas of known stem attack (past and present) by factors such as stand age, density, species composition, site nutrients and moisture, elevation, rate and success of periderm formation and compare with adjacent areas which have never been stem-attacked.

2) Characterize susceptible and non-susceptible trees within areas of stem attack using physiological-biochemical parameters such as water stess in the crown and stem, rate and success of periderm formation, bark amino acids and alkaloids.

Hopefully, this system will produce management recommendations which will minimize mortality in mature stands, as well as facilitate successful restocking of high elevation cutovers with Abies.

A study at Simon Fraser University has shown that populations from various parts of North America are significantly different morphometrically. A key to North American populations and the development of a similarity index among populations may help to explain some of the high degree of variability observed between regions.

Dave L. Overhulser, University of Washington, discussed some factors affecting behavior and abundance of Pissodes strobi in coastal spruce plantations. Observations on the behavior of the adult weevil indicates that the spring activity pattern of this insect is strongly affected by temperature regimes within two miles of the coast. Data was presented showing that natural host resistance associated with site conditions on the northern Olympic Peninsula and within two miles of the coast is an important factor inhibiting the buildup of weevil populations.

Les McMullen discussed damage hazard due to P. strobi with a map based on the amount of summer heat required by the insect for development from egg to emergence. The insect requires approximately 890 degree-days above 7.2°C. Such amounts of summer heat rarely occur on the extreme west coast and northern areas of Vancouver Island where damage has been negligible or absent, or on the Queen Charlotte Islands where the insect has never been found. Also discussed was simulation model of the interaction between P. strobi and Sitka spruce which has been valuable in understanding the damage caused by the insect and has provided an insight into problems associated with chemical control.

TWENTY-SEVENTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

Wemme, Oregon
March 1 - 4, 1976

WORKSHOP: Population Sampling - Estimation, Evaluation, and Prediction.

Moderator: Bill Waters, University of California, Berkeley.

This session had a well-balanced mix of researchers, survey specialists, and control specialists. Its purpose was three-fold: (1) to present information on methods currently in use and/or development, (2) to present ideas and/or information on innovative methods that might have applications in research, surveys, or control operations, and (3) importantly, to demonstrate the risks involved (in terms of time and $) in using methods of population estimation, evaluation, and prediction with unknown or very large errors of estimate - especially methods for which the cause(s) of the variances are not known and/or not accounted for.

The discussion focused on the four primary uses or objectives of sampling forest insect populations: (1) to estimate an average, or total, number of insects present at a particular point in time and place, (2) to correlate with one or more other factors having special meaning to the investigator or user (tree or stand factors, damage, natural enemies, treatment effectiveness, etc.) where insect density is the dependent variable or an "independent" variable, (3) to provide a time sequence of insect densities (within or between generations) for evaluation of mortality-causing agents or processes or for prediction of future changes in density, and (4) to test, or validate, models of the dynamics of the insect population, the

impact of the insect on forest resource values and/or management objectives, the outcome of alternative control strategies, etc.

The tradeoffs between accuracy, precision, and time-cost factors were discussed with respect to research, survey, and control objectives and constraints.

It was pointed out that in the conduct of the foregoing functions, estimates of pertinent population parameters generally were needed also for the natural enemies of the pest insect(s), their host trees and stands, other destructive agents (e.g. diseases), and other entities in the forest ecosystem.

Some common problems to be met in sampling forest insect populations were described. These include (1) defining the population universe and the sampling universe, and specifying (quantitatively or qualitatively) the relationship between them, (2) specifying the objectives of the sampling plan, the confidence limits desired, and other criteria affecting the design and conduct of the sampling under forest conditions, (3) distributing the samples in time and space without bias, (4) avoiding the pitfalls of pooling data, and (5) handling the errors of successive sampling, etc.

Specific cases of sampling defoliator populations were discussed in some detail. Val Carolin described current procedures used for the western budworm; Dick Mason described the procedures developed for the Douglas-fir tussock moth. The biological background, the assumptions relating thereto, and the statistical aspects of each procedure were discussed. Needs for further research and field testing were clearly indicated. Bob Coulson, Gene Pulley, and John Foltz described their recent work on the development of new, improved methods of sampling within-tree populations of the Southern pine beetle. The procedures developed thus far include methods of estimating

both surface area of the infested portion of the tree bole and the beetle density. The various surface area and beetle density estimation plans have been combined and evaluated with respect to their precision and efficiency in estimating total within-tree populations. The topological mapping procedure developed by Pulley et al is used as the reference basis for comparing the errors of estimate of the other sampling procedures.

Following is the list of participants in this Workshop:

Harry Anderson
Doug Parker
Scott Tunnock
Walter Salazar
Bob Coulson
John Foltz
Gene Pulley
R. F. Luck
Bob Heller
Mark Brown
Scott Overton
Clifford Ohmart
W. G. Evans
M. Stock
B. Hynum
G. Simmons
G. M. Howse
Les McMullen
Lyn Frandsen
Gene Lessard
M. W. McFadden
R. Carlson
P. G. Mika
W. Cole
Fred Stephen
R. Wiggins
R. Blair
Dick Mason
Thomas Dodd
D. L. Kulhavy
John Wortendyke
R. Ryan
Denny Ward
R. Schmitz
Dick Washburn
E. Nebeker
Bruce Hostetler
V. M. Carolin
D. L. Dahlsten
Russell W. Clausen

WORKSHOP: PRO AND CON OF CHEMICAL CONTROL

Moderator: Bill Klein

Participation: There were approximately 35-40 individuals attending the workshop. Prior arrangements were made with a few individuals to present their views on spruce budworm control, rather than on chemical control in general.

The budworm problem was more topical since several large-scale control projects are planned in the United States and Canada during 1976. Dave Leonard, University of Maine, presented the budworm situation in Maine, including some socioeconomic ramification; A. P. (Randy) Randall, Chemical Control Research Institute, Ottawa, explained the control situation in eastern Canada; Dave McComb and Don Curtis, Region 6, discussed the planned control effort in eastern Washington; Fred Wagstaff, Region 4, presented a paper on the economic aspects of control programs; Boyd Wickman, P.N.W., showed color slides of Douglas-fir tussock moth damage during and following an outbreak; and Bill Klein gave a paper on how management policies effect a benefit cost analysis. Other than the four presentations which follow, the discussions were open and informal.

THE MAINE SITUATION: Dave Leonard

Large areas of spruce-fir forests in eastern North America are infested with spruce budworm, including about 5.5 million acres in the northern half of Maine. The present means to combat this outbreak is with aerially applied insecticides.

The decision to treat with insecticide is based on several criteria. Infested areas are delineated by aerial and ground surveys by Maine Bureau of Forestry personnel. Hazard ratings are developed based primarily on past defoliation, present tree condition, and estimates of the next year's budworm populations. Areas of high hazard rating, i.e., those areas where substantial tree mortality will occur if no action is taken, are marked for treatment. With this system, heavy budworm feeding has occurred prior to the first insecticide treatment and trees are in poor condition.

The purpose of insecticide treatment is to maintain at least 50% current years growth of foliage. The budworm population reduction is usually in the 80 to 90% area, not enough to reduce the population in the succeeding year, but sufficient to keep most

trees alive. In 1976, 3.5 million acres are being considered for treatment with Sevin-4-oil if a 3/4 lb./acre rate is permitted; otherwise 2.6 million acres will be treated at 1.0 lb./acre.

Although entomologists document population levels and hazard ratings, the decision to treat is based on economic, political, and sociological considerations. The spruce-fir forests in Maine are heavily utilized by a forest products industry that requires a continuing supply of pulp wood and lumber for its mills. This industry is probably the major economic factor in northern Maine. The consequences of no action are well documented in current and historical data on budworm impact. Where an outbreak becomes established in mature stands and is allowed to run its course, in about 5 to 8 years after the initial noticeable defoliation most of the merchantable fir and about 1/2 of the spruce is dead. Many of those trees remaining sustain crown mortality and in opened stands are more susceptible to windthrow and fire.

The problems with a treatment strategy concern the high cost of treatment, the allocation of the state, federal, and private share of the treatment cost, the limited number of registered insecticides, environmental side-effects, application technology including delivery systems and the treatment of large blocks which frequently include a large percentage of non-vulnerable or non-susceptible stands, and the maintenance of budworm susceptible forests through insecticide treatment which results in the prolongation of outbreaks.

SOME OBSERVATIONS ABOUT ANALYSIS OF FOREST PEST MANAGEMENT PROGRAMS: Fred J. Wagstaff

Introduction: I would like to begin by briefly summarizing what seems to be some of the most important aspects of the spruce budworm situation. First, we seem to have reached a plateau with regard to gaining knowledge about this forest-pest species. There remain many unanswered questions about the population dynamics of the budworm. What are the causal factors preceding an outbreak? Climatic release appears the most plausible answer at this time although many complicating factors such as stand condition also seem to have an effect. There are still significant gaps in our knowledge and I would hope entomologists can provide answers soon.

Secondly, the problems of control seem more centered around economic and political factors than based on sound biological data.

Some of these political and economic considerations are the points I would like to cover.

Third, the approach to a temporary control solution is probabilistic in nature and must be treated as such. We just don't have enough knowledge to predict with mathematical certainty the outcome of our control actions on the dynamics of timber stands or insect populations.

The fourth point is that any management of forest insects is complicated by unclear management objectives which are in a continuous state of Flux. Our strategies for management of insect populations, timber stands, and other resources are constantly evolving and represent a series of dynamic variables to be considered.

Fifth, the insect management problem is complicated in the Intermountain Region by various species compositions, timber classifications, management plans, land use plans, functional management plans, climatic variations and geographic differences.

Problem Statement: Briefly, the problem is how to design a study outline which will provide necessary and sufficient information to land managers about forest insects to enable objective decisions to be reached. There are many issues or problems which could be studied but the main issue seems to boil down to a control-no control point. Even this is not as simple as it seems and perhaps the terms are misleading.

Control may be defined broadly as actions taken by man to affect insect population dynamics in a predictable and prescribed manner. Non-control would mean letting nature take its course with no direct manipulations by man. A more restrictive definition I choose to use is control= use of chemical agents; no control= no direct interference with natural forces affecting insect populations.

The more relevant issues in pest management seem to be as follows:

1. What would be impact on timber growth, yields, reproduction, and other resource values with and without control measures?

2. Would the probabilities of fire occurrence be changed under a control-no control decision?

3. What would be the population dynamics of the insect under both conditions?

4. Are there alternative uses for the funds used for control which could affect timber growth, yield, reproduction, etc.? Some possibilities might be fertilization of highly productive sites, thinning of stagnant stands, genetic tree improvement, reforestation of sites not fully stocked.

5. Can we combine all of the numerous variables into a systematic decision framework which is simple enough for managers to conduct and understand?

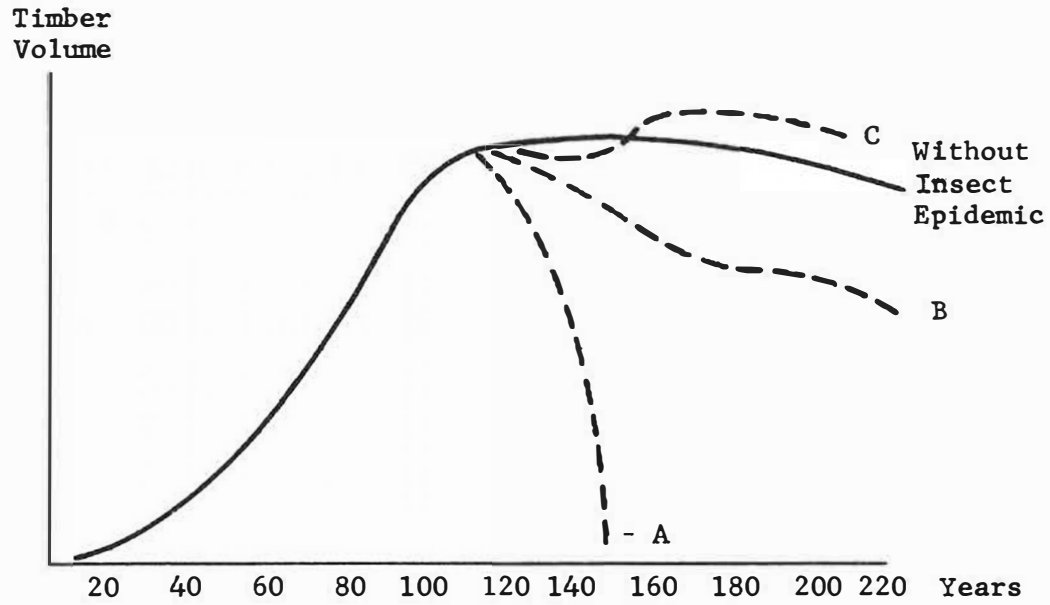
6. Is the biologic and physical information attainable to accurately predict outcomes and does it come in a form to which monetary measures can be applied?

One can readily see the issues are extremely complex and overlapping. We are dealing with biological variables, climate variables, economic variables, political variables, and others. Is it possible to cope with this high level of uncertainty? Hopefully, order can be brought from chaos and we can begin to center our attention on the important factors and reach decisions based on sound biologic data rather than emotion.

The basic consideration of any management plan is to compare alternatives. For simplicity I have restricted their discussion to two courses for action; control-no control. We then could state the question differently by asking what is expected under the with and without control conditions.

It seems self evident that we must consider broad averages for our estimates and that many predictions might prove false because we have so many uncontrolled variables to deal with. A host of environmental factors will be acting simultaneously affecting both insects and the timber stand.

Perhaps some simple graphics may be helpful.

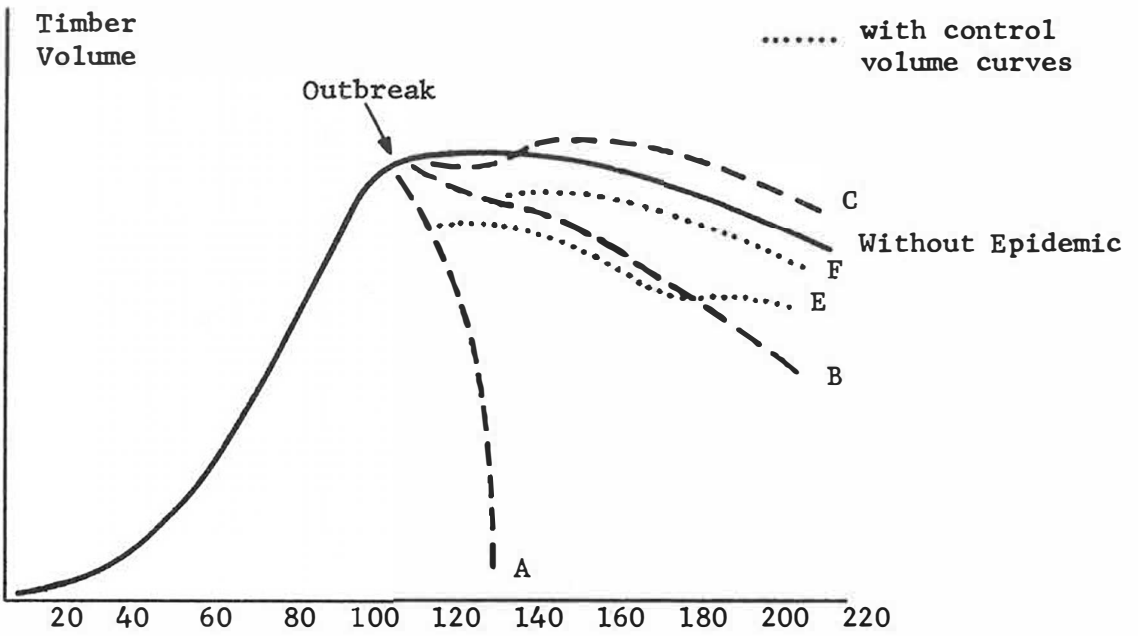


This hypothetical stand would follow a logistic type growth curve without an insect epidemic and would reach a maximum volume at about 80 years of age. The standing crop or harvestable increment would be x. This volume could be effectively stored on the stump for some period of time before harvesting.

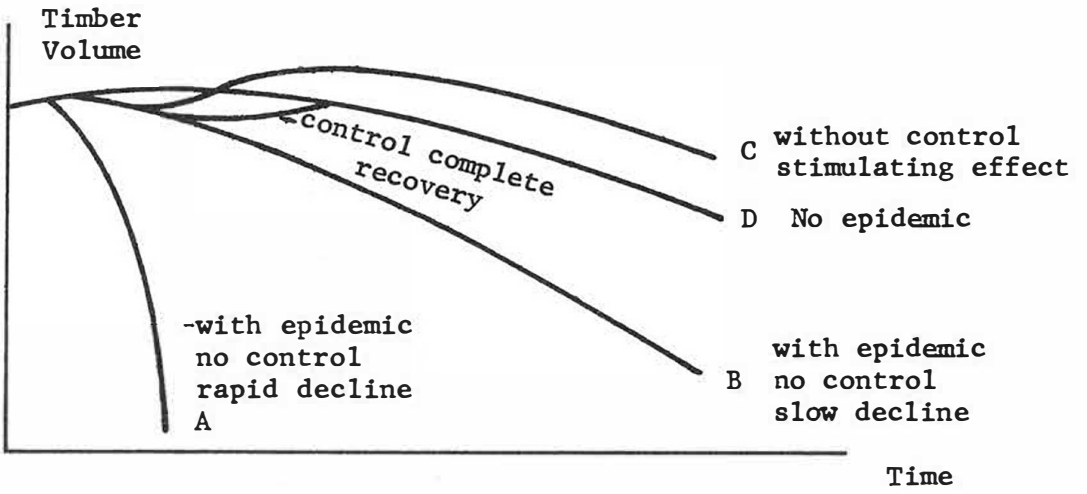
The dashed lines represent the effects on stand volume due to an epidemic. What these "with" curves look like is the critical question.

The entomologist and silviculturist must determine what the shape and slope of these curves are and also the volume for the axis. The curve labeled A represents a rather sudden and irreversible increase in mortality. Curve B represents a reduction of growth at the time of the outbreak and no recovery. Curve C would represent a reduction of growth for a period and then a period of accelerated growth.

If the damage curve looked like A the loss is relatively easy to see. With the B type curve it is also fairly clear. With a type C curve the only damage is a time lag to the point of maximum volume.



Using the same abstraction of a timber growth curve with control, we must also determine the shape of curves labeled E & F. Doing so would isolate the effect of control. Perhaps a third graph would clarify the point.



Under this situation the volume saved by control would be the area under the D curve if the without control were A. (D-A = saved volume); without =B (D-B) without = C (D-C). We can readily see that D-A > D-B < D-C. Put simply, the greater the without damage the greater the amount which could be saved with a successful control program.

So much for the simple part of the problem. Intuitively, we can see that control might save considerable amounts of timber if the without conditions increased mortality greatly or significantly reduced growth. To introduce a very important variable we must consider another time related factor.

Timber can be harvested when it reaches a suitable size or for a considerable time thereafter. Given sufficient time stands will undergo a successional change with the old growth being replaced. The question is really whether we would harvest the timber saved (or lost) during the time preceding its natural demise. Indefinite storage of timber on the stump is not possible although the time frame could be quite long before some other factor would bring about mortality.

Some questions which need to be answered at this point are:

Is a market available for the timber saved?
If so, when is harvest expected?
Is salvage of dead material possible?
How long is salvage possible after death?
What are probabilities with and without control of other events affecting ultimate yield (fire, windthrow, disease, other insect outbreaks, etc.)?
What other resource values are affected? How much?

Perhaps the final complicating issue is the necessity of introducing some economic questions into the problem. We need to decide the following:

What is the proper discount rate?
What is the period of analysis?
What per unit values should be used?
Should secondary benefits and costs be counted?
When are costs and benefits incurred?

Proposed Study Plan

Biologic and Physical Data needed:

1. Population dynamics of insect population.
2. Estimates of control probabilities.
3. Time of control.
4. Duration of epidemic without control.
5. Effect on yield with and without control
6. Size of salvage material.

Management Data needed:

1. Expected harvest schedule under with and without conditions.
2. Market availability.
3. Stand classification, standard, special, marginal.
4. Timber management objective.

Simple Model

The objective of an economic analysis is to determine the differences in net present worth of the with and without control alternatives.

NPWC - NPWNC = Value of control alternative

Taking the control alternative we would proceed as follows:

1. Yield per time period x value per unit x discount factor = PWY
2. Cost of control x discount factor - PWC
3. Other benefits x unit values x discount factor = PWO

PWY + PWC + PWO = NPWC

We would then proceed to analyze the with, the without control alternative in a similar manner.

There are some major assumptions which must be made in applying their type of model. Some of the most important are:

1. The yield volumes will be available for harvest as predicted.
2. Values will remain constant over time.
3. Other resource benefits and costs can be accurately measured.
4. Insect population will behave as predicted.
5. Actual harvest will take place.

Let's look for a moment at some of these assumptions and the effect they may have on our choice of an alternative.

1. Yield volumes will be available for harvest. We are assuming that some other factor such as fire, wind, insects or administrative decision will not remove the timber. This then becomes a probabilities type estimate and not a certainty. The further into the future

the more likely some other chance occurrence would reduce the volume available. The closer to the present time we can plan harvest the greater the probability of the volume being as predicted becomes. Another point in that volumes in the future will add to present worth values less than those planned for harvest earlier. The discount factor rests heavier on future values. For example, using a discount rate of 10% reduces present worth of $1 to $.62 at 5 yrs., $.39 at 10 yrs., $.009 at 50 yrs., and $.00007 at 100 yrs. Since costs for treatment are incurred at the beginning of the analysis they are used at full value.

2. Values will remain constant over time. This assumption is more properly stated by stating values will change in the same proportions over time. This assumption becomes critical because we are really saying that demand for timber will be in the same relative position to other goods or services at some future point. Implicit in this assumption are other assumptions about technology, consumer tastes and preferences, income, etc. We are assuming there will not be significant technological change which could utilize smaller trees, dead trees or total cellulous fiber. We are saying wood in the form of dimension lumber will remain a major component of housing construction; substitute building materials will not be developed and people will want to use wood. We are also assuming that people will have sufficient income to purchase wood products.

3. Other resource benefits and costs can be accurately measured is a very bold assumption. Many of the values which are involved are not easily quantified. Natural beauty is a prime example. What impact will the infestation have on recreation uses, wildlife populations, water quantity and quality, the basic soil resource, visual characteristic, need for roads, fire protection, ad infinitum. The point is that many impacts may be very subtle and any differences hard to detect. We must, however, attempt to support any conclusions with facts not emotions.

   A good example is the feeling that insect mortality will adversely affect the visual resource and recreational use. Yet we see Grand Teton and Yellowstone National Parks with significant and highly visible insect mortality and continually growing visitations.

4. Insect populations will behave as predicted. This assumption implies we can predict population dynamics with some degree of accuracy. Were this possible, our control-no control decision could be planned for an optional solution. Perhaps presuppression could be effectively used.

   This assumption is critical because any significant deviation may completely reverse the decision. We have many examples of control measures being applied to populations which were in the process of collapse. This assumption also implies we can determine and predict impact of insects on growth, yield, mortality and reproduction of stands. If we cannot do this our control-no control programs might well yield the same results if applied randomly to forested areas.

5. When we assume a volume saved or lost, we must tie to actual harvest. If timber is not harvested or used what would be the difference between alternatives? If our objective is to maximize sustained yield we are saying the resource must be used to yield a benefit. We must modify our impact assessments by physical and administrative factors that reduce harvest. Our current timber classification system does not put all timber volume into the market system. Some areas have their potential yield reduced because of management considerations or other resource uses. Some areas are set aside as wilderness. Some areas cannot be harvested with standard methods which means higher cost techniques. Exotic logging is expensive and would be restricted to higher value species and individuals.

Conclusions

There are several analysis techniques and programs currently available to make analyses of insect management programs. Any systematic decision model will require data from several resources and disciplines. We know the state of the art varies for several disciplines which are relevent to insect management but we must proceed.

It would seem the best approach would be an interdisciplinary team composed of foresters, entomologists, economists and others as needed. We must have sound biological data and management data to make sound decisions. To date, little progress has been made and it is rather appalling to see so little effort being devoted

to control-no control decisions when the risks are so great and the investments are sizable.

In the bibliography which follows (omitted) there were only two articles dealing with the economics of control programs. There were few studies that dealt with actual damages over time and none which attempted to relate actual losses to harvest schedules.

There is a real need for better biologic data coupled with management data and economic data. We must proceed on a systematic basis to obtain this information so comparisons of control and non-control alternatives can be made. It is only the differences between the two which are important to reaching a sound decision.

COMMENTS ON STAND RECOVERY: Boyd Wickman

I would like to present just two points for consideration.

1. We really don't know how much stand growth loss (notice I didn't say tree damage) through a rotation the spruce budworm is causing--indeed some areas treated may never be logged and to say we are saving recreation values is ridiculous.

2. We really don't know how much damage we are causing in the forest ecosystem by spraying large tracts of forest with biocides. Therefore, how can we justify spending dollars and petrol energy resources on a problem that may not be a problem, using a technique that may be creating more problems? My suggestions--spend the amount of money equivalent to one 500,000-acre aerial control project on determining the magnitude of the problem and what might be saved by treatment. And, learn enough about the biocides being used so that we can put some cost figure on the side effects.

MANAGEMENT RESTRAINTS AND THEIR ROLE IN A BENEFIT/COST ANALYSIS: William H. Klein

A benefit/cost analysis is required for all forest insect and disease control programs. Before the programs can be undertaken, the benefit/cost ratio must be favorable; i.e., a definite savings must be shown.

With spruce budworm control, there are many factors that go into a benefit/cost analysis. They may be divided into two groups: intangible and tangible. The intangible includes those factors that cannot be readily identified or measured, including aesthetics, effects on specific forms of wildlife, water yield, and to some extent, fire hazard. The tangible factors, or those identifiable and to some extent, measurable, include timber damage, growth reduction, reforestation, and possible recreation (visitor day losses), to name some. Even with these factors, unfortunately their measurement and analysis is still more of an art than a science.

My remarks will be limited to only one and probably the most tangible of these myriad factors that are woven into a benefit/cost program--the timber resource. This boils down to two major considerations or tenets: (1) the quantity of timber protected and (2) the quantity that will eventually be utilized.

Past budworm control justifications, particularly those during the DDT era, emphasized the volume of timber threatened. In other words, the computation involved the average volume per acre multiplied by the number of acres treated. I'm not sure just how this was supposed to be interpreted, but I assume that an impression was created that if the infestation was not treated, either the entire area and/or volume would be destroyed by the budworm.

Since then, however, our approach is now more realistic and our analytical procedures are more sophisticated. Instead of volumes threatened, the approach now is volume lost from mortality, and equally important, from reduced growth. Comparisons are made between volume lost with control and volume lost without control. One problem still remains, however, and that is the total quantity of volume involved. Of the few budworm impact studies and control programs to date, it has been assumed that the volume lost (or saved by control) is the volume per acre multiplied by the total infestation or control area. In some control plans, this overall figure is reduced slightly due to less than full efficacy of control. The basic assumptions here, and it is important that we examine these assumptions in some depth, is that control is effective and that all (or most) of the timber resource saved will be eventually utilized. Let's assume the first assumption is true, that control is effective, but now let's examine the second assumption; that is, that all of the resource saved (or protected) can be utilized.

We are now faced with an inevitable truth, and that is that we will probably never be able to utilize all or even a large part

of the potential timber resource in the National Forest system, whether that resource be in a management unit, Ranger District, or budworm control area. So as to illustrate these management constraints as well as some computations necessary for a realistic basis of a benefit/cost analysis, I have suggested a hypothetical Western Spruce Budworm Control Program. Again, I need to emphasize that we must assume that control is effective and that we have saved x board feet per acre over that if there was no control. What we now need to know is just how much of this "saved" timber can we hope to utilize?

Figure 1 (not included) shows the distribution and intensity of spruce budworm defoliation on the Payette National Forest, Idaho, during 1975. The Payette, incidentally, has a long history of spruce budworm beginning back in 1922. Control with DDT was undertaken on 216,000 acres in 1955, 98,110 acres in 1956, and 374,180 acres in 1957. I think it is safe to say now that the infestation has resurged!

Figure 2 (not included) shows the proposed timber management classifications for the Payette. Very briefly, here are some definitions:

STANDARD COMPONENT (GREEN). That area designated for intensive management. No serious deterrents here, other than a limit on size of clearcuts, for example.

SPECIAL COMPONENT (YELLOW). Those areas that receive special attention because of environmental considerations. Under multiple use planning, this component included most of the intermediate zone and all of the travel, water, crest and riverbreak zones not specified as marginal.

MARGINAL COMPONENT (BLUE). Areas that contain commercial timber but have poor access or are uneconomical by today's standards. The operable areas will probably require aerial yarding systems.

DEFERRED COMPONENT (PINK). Areas proposed for study as wilderness. The timber volumes, as are those in the reserved category, are not included in the potential yield (allowable cut) base.

RESERVED COMPONENT (ORANGE). Idaho primitive area.

Figure 3 shows the proposed control area superimposed on three Ranger Districts and four management components (reserved not included). A breakdown of acreage by Ranger District and management component within the proposed spray area is shown in Table 1.

Not all of the area within the control boundaries is commercial forest area. Table 2 shows the percent commercial area by Ranger District, ownership, and management component.

Since the concern at this point is with commercial forest area, the next step is to reduce the total area, and its various components, by their respective proportion of commercial forest. Table 3 shows this reduction, including the omission of commercial forest area in the deferred category. This now represents approximately 153,000 acres of commercial forest area within the proposed spray boundaries, or 52 percent of this area and its timber resource, and considering the various management restraints, how much can we effectively and practically utilize? It is reasonable to assume at this point in time that the probability of utilizing the timber resource in deferred and scenic area is nil. What about the other management components? What is the probability that we can fully utilize the timber resource in the other components during the next 120 years?

After conferring with Timber Management specialists, and compromising their estimates, the following probabilities were derived (Table 4). The amount of commercial forest area was then adjusted accordingly. The commercial forest area that we can reasonably expect to utilize during the rotation period is 114,469 acres, or 41 percent of the spray area. If we assume that with treatment we protect .100 MBF/acre (annual growth rate of Douglas-fir is 151 MBF/acre/year) with a present estimate stumpage value of $15.00 MBF, the calculation would look like this:

1. $ Value Protected =

$$\frac{\text{Volume Protected } (.100 \text{ MBF/A}) \times \text{Present Stumpage Value } (\$15 \text{ MBF}) \times \text{Utilizable Area } (144{,}469 \text{ Acres})}{\text{Total Spray Area } (293{,}760 \text{ Acres})} = \underline{\$0.58/\text{Acre}}$$

2. Amount Required for Break-Even Ratio =

$$\text{Control Cost } (\$7.00/\text{A}) + \text{10\% Savings } (\$0.70/\text{A}) - \text{Value Protected } (\$0.58/\text{A}) = \underline{\$7.12}$$

(Value Protected: Not Discounted)

It is apparent that in order to obtain a favorable ratio, we must plug in other values. In this example, the present value of timber protected falls far short of the desirable threshold.

In closing, I would like to again emphasize that although this was only an exercise, it involved certain management principles and constraints that were heretofore not considered in benefit/cost calculations. Other Regions and areas may have essentially the same constraints, but differ in degree; however, the principle is still the same.

TABLE 1. Total Spray Area (in acres) by Management Components and Ownership, 1976

		Management Component				
Ranger District	Private	Standard	Special	Marginal	Deferred	Total
Council	17,760	24,800	21,120	--	--	63,680
Krassel	1,760	15,840	44,800	39,200	40,960	142,560
McCall	18,720	15,360	13,280	2,880	37,280	87,520
Totals	38,240	56,000	79,200	42,080	78,240	293,760

TABLE 2. Percent Commercial Forest Area by Ranger District, Ownership and Management Components.

		Component			
Ranger District	Private[1/]	Standard	Special	Marginal	Deferred
Council	90	71	59	--	--
Krassel	90	94	48	77	--
McCall	90	92	51	23	--

1/ Data not available; conservatively assumed.

TABLE 3. Area (in acres) of Commercial Forest Land in Spray Area

Ranger District	Private	Component: Standard	Special	Marginal	Deferred	Total[1/]
Council	15,984	17,608	12,461	--	--	46,053
Krassel	1,584	14,889	21,504	30,184	--	68,161
McCall	16,848	14,131	6,773	662	--	38,414
Totals	34,416	46,628	40,738	30,846	--	152,628

1/ 52 percent of total spray area (Table 1.).

TABLE 4. Reduction in Commercial Forest Area of Various Management Components by Percent Probability of Harvest During Rotation Period.

Component	Probability of Harvest (%)	Commercial Forest[1/] Area (acres)	Adjusted[2/] Area (acres)
Private	95	34,416	32,695
Standard	95	46,628	44,296
Special	50	40,738	20,369
Marginal	75	30,846	23,134.
Deferred	--	--	--
Totals		152,628	120,494[3/]

1/ From Table 3.

2/ 41 percent of total spray area (Table 1.).

3/ Estimate of treatment efficacy on 120,494 acres is 95%; therefore, total acres with probability of complete utilization during rotation ages is 114,469.

WORKSHOP: ECONOMICAL AND SOCIOLOGICAL ASSESSMENT FOR BARK BEETLE

Moderator: Donn Cahill

Participants:

Gene Amman	Wayne Brewer
Henry Yang	John Pierce
William Ciesla	Lee Ryker
Douglas Parker	Fay Shon
John McLean	Paul Buffam

This was an informal workshop without any prepared papers. A brief description of the Methods Application Group at Davis, California was given, including a rundown on their expertise in insect and disease impact evaluation. Seven of a planned ten specialists were aboard. These unit experts provide leadership in standardizing data collection methods for assessment of impact of insect and disease activity.

There was a discussion on computer mapping and what would be advantageous to the land manager, entomologists and the funding unit. Also included was the possible use of aerial photos and problems with turn around time. There is a problem of determining impact effects other than those on timber. Some participants were hoping that the sociological assessment would be helpful but this did not generate any light on the problem.

A brief recap was presented of a southern pine beetle impact study. This study includes development of a model. Spruce beetle impact was briefly discussed and it was pointed out that some problems exist in evaluating some resource values.

Workshop: SILVICULTURAL PRESCRIPTIONS FOR DENDROCTONUS BEETLES

Moderator: J. M. Schmid

Silvicultural prescriptions for Dendroctonus beetles are generally lacking. Most prescriptions exist because they are prudent ways to culture the forest and not because they were designed to reduce the degree of infestation of Dendroctonus beetles.

Western pine beetle.--C. J. DeMars noted that the California risk rating system developed for mature stands on the dry eastern slopes of the Sierra mountains does not apply on the moister western slopes. Probably because moisture stress is constantly high on the east side and variable on the west side.

Harvest prescriptions for second growth stand exist, but were not derived using pest (ento-pathologic) data. When crown closure is achieved, cut 45 percent of basal area or alternatively cut to that percent of basal area which with 10 years' growth will return the stand to 90 percent of maximum basal area.

In the McCloud Flat area where the 80-year stands had a closed canopy, basal area approached 170 ft^2/acre. The stands came under severe beetle attack. After stands were thinned to 90 ft^2/acre, losses were greatly reduced.

Douglas-fir beetle.--J. A. Rudinsky stated that the Douglas-fir beetle is definitely a secondary insect in the coastal forests invading mostly dying or freshly windthrown trees in which it develops into epidemic populations. In the Rocky Mountain region the beetles can invade and overcome drought-weakened trees. Although there are differences in terpene composition between the coastal and interior types of Douglas-fir, which may contribute to the behavioral differences of the beetle, the host condition at the time of beetle attack seems to be an important factor. After the population builds up into epidemic proportion, normal healthy trees are killed in both regions regardless of their physiological conditions.

Referring mainly to the Douglas-fir beetle in coastal forests, Rudinsky noted that stand improvement plans developed by the U.S. Forest Service for Region Six (FS 1965) visualize thinnings at 15-year intervals, and reducing the basal area of the stand by 625 ft^2 for site II down to 265 ft^2 for site V during 110-year rotation. This thinning will result in greater increment and in more vigorous stands, which doubtless will lessen destruction by the Douglas-fir beetle. Vigorous young stands are more resistant

to windthrow, but windthrow will still occur in these stands and the phloem of such trees (10 in dbh and above) is an excellent breeding material for the beetle. However, in more intensively managed stands the following practices can be used or integrated with the regular thinning operation to prevent or lessen beetle population buildup.

1. Promoting natural increases of the parasite -- Coeloides brunneri. This wasp deposits the egg on the Douglas-fir beetle larvae through the thin bark, and the developing parasite kills the larva. With shorter rotation of Douglas-fir, there should be more thin-bark host available for this parasite. Also, this wasp has 2 to 3 generations per year, the first generation emerges in July, and one-half of the second generation emerges in August. Providing fresh breeding material by regular thinning for the summer attack of the Douglas-fir beetle will automatically also provide host for the second generation of the parasite and thus augment its population. Details are provided in Ryan and Rudinsky, Can. Ent. 1962, 94:748-63.

2. Sanitation and trap tree approach. Douglas-fir beetles are always attracted to fresh blowdown, freshly cut trees, or fire-killed trees, preferring scattered, shaded windthrown or cut trees in which their numbers increase to outbreak proportion. Timely removal of such infested material (before the progeny emerges) is the surest way to prevent outbreak. After catastrophic blowdown, however, complete sanitation is not possible. Therefore, unless some unusual climatic conditions interfere, the population increases greatly in the blowdown, and invades living trees upon emergence if enough breeding material on the ground is not available. Because of this beetle preference for fresh down trees, trapping the increased population by providing trap trees has been considered and compared to the century-old trap tree method used in Europe against Ips typographus. There, three series of trap trees are provided during the flight of the beetle, the number of trees cut depending on the amount and intensity of the invasion of the previous year or in the preceding series. It seems that in the Douglas-fir region at least two series would be necessary to absorb the spring flight and also the summer flight. To be effective, it appears that the entire area of outbreak would have to be treated and the timely removal and disposal of the trap trees assured. An attempt along these lines was made during the outbreak resulting from the Columbus Day storm (B. Howard, It's up to the logger, U.S. Forest Service R-6, November 1964). The trap tree approach is not currently practical in many areas of the Douglas-fir region. Among the reasons to be given are: lack

of research on this method in the region; lack of roads and intensive management; considerable beetle emergence (up to 30 percent) in September, which shortens the time for sanitation, etc. Cutting trap trees during high beetle population could be well integrated with the thinnings for stand improvement.

3. Use of attractive or inhibitory pheromones. Studies show that 3-methelcyclohex-2-en-1-one (3,2-MCH, formerly called MCH) can prevent beetle attraction to susceptible or attractive host material. The substance is being developed for field use and may be a useful tool in the hands of the forest manager to prevent buildup of beetle population in windthrown areas or to protect susceptible stands from beetle invasion.

There are other substances that may be useful. For my colleagues Drs. Morgan, Libbey, Putnam, and Ryker, I can announce the identification of an isomer of 3,2-MCH, namely 3-methylcyclohex-3-en-i-one (3,3-MCH). The substance is released by the male Douglas-fir beetle together with 3,2-MCH and also frontalin. This isomer is unknown from natural products and its role in the multiplex pheromone of the Douglas-fir beetle is being studied.

M. Furniss emphasized that in the Intermountain Region the Douglas-fir beetle can develop an outbreak population from windthrown material in the same way as in the Pacific Northwest.

Mountain pine beetle in lodgepole pine.--G. D. Amman and M. D. McGregor noted that the mountain pine beetle generally kills trees over 12 in. in diameter at breast height and with a phloem thickness greater than 0.1 in. Beetle populations in stands with these characteristics will increase while populations in stands of lesser diameter and phloem thickness will die out. Thus, these characteristics could form the basis for a silvicultural prescription. Preliminary results of a thinning study in progress on the Gallatin NF, Montana, in which all the trees above 7 in., 8 in., and 12 in. dbh as well as those with a phloem thickness of 0.10 in. or greater were to be removed in 4 different 40-acre tracts (one characteristic for each tract) indicated a reduction in beetle infestation in tracts that were cut. The diameter and phloem information has been used on stands in Colorado by Cole and Cahill. Removal of the larger diameter or thicker phloem trees appears to be a useful prescription to reduce losses. However, if all the trees are in the large diameter or thicker phloem category, then selection cutting for specific diameter or phloem thickness will not work and clearcutting is the only alternative.

Spruce Beetle.--No silvicultural prescriptions currently exist. Since the beetle prefers older, large diameter trees and outbreaks seem to develop when the stand has a basal area value of over 150 ft^2 per acre and over 70 percent of the canopy is spruce, these characteristics could be used for a set of prescriptions. Knopf noted that block clearcutting was not desirable in the northern Rockies.

WORKSHOP: DETECTION, MONITORING, AND SURVEY METHODS
Moderator: Steve Kohler
Participants: Wayne Bousfield, Tom Gregg, LeRoy Kline, Mark McGregor

Computer Mapping of Aerial Insect & Disease Surveys - Wayne Bousfield

We are currently working a system to digitize aerial insect and disease surveys for the purpose of computer mapping and for acreage determination.

Currently, we do not provide a map for all interested parties and our acreage calculations are becoming a burden. We feel that a digitized mapping system is essential if the detection work is to be useful to all land managers.

Basically there are three types of computer mapping systems, (1) line segments, (2) closed polygon, and (3) grid format. We are looking closely at the polygon system because it seems to have fewer problems. Once we have the ownership in digital format by units of land (National Forests, State Forests, Indian Lands, etc.) then the pest problem layer is updated each year. We are looking for a 7 to 10-day turnaround time between aerial survey completion and providing all land managers with a map of pest problems.

Light Traps For Detection of Forest Nursery Pests - LeRoy Kline

The use of light traps as a means for monitoring and detecting populations of forest nursery pests was discussed. The Oregon Forestry Department has tried this method of population monitoring on a limited scale with mixed results. More work is needed to refine techniques and determine if the use of light traps will be a valuable tool for survey and monitoring of forest nursery pests.

Mountain Pine Beetle Damage Survey, Second-Growth Ponderosa Pine Stands, Lolo National Forest and State & Private Lands - Mark McGregor

Mountain pine beetle, Dendroctonus ponderosae Hopk., developed to epidemic levels in second-growth, 60 to 80 year old ponderosa pine stands on the Ninemile Ranger District in 1969. The infestation increased through 1971 and encompassed 12,141 ha. (30,000 acres). Heavy infestation occurred on 1,052.2 ha. (2,600 acres) within

this area. A two-stage survey was used during 1972 and 1973 to stratify the infestation and obtain tree and volume loss estimates. This method was used to eliminate the need for surveying the whole infested area.

Survey Methods

The Division of Engineering, USFS, Missoula, Montana, photographed the infestation on a 9-inch format with a Zeiss RMKA 15-23 aerial camera equipped with a 6-inch focal length lens and a K-36 cc. filter. The film was Ektachrome MS Aerographic 2448 color positive. Two levels of color photography were utilized for photo interpretations. Full coverage on 30,000 acres was made at a scale of 1:15,840. A semi-controlled mosaic was obtained from the photos and area of heavy infestation was stratified. Low-level photography at a scale of 1:6,000 was used for precise counts of 1972 and 1973 faded trees. Interpretations were made on a total of 117 0.20 ha. (½-acre) plots in 1972, and 323, 0.20 ha. (½-acre) plots in 1973, using an old Delft scanning stereoscope. Twenty 0.20 ha. (½-acre) plots were then selected by a computer program PPSORT for ground cruising each year. This program selects on probability proportion to size; that is, plots with large counts of red-topped trees and fading trees had a greater chance of being selected. Plots selected by PPSORT were then 100 percent ground cruised. Within each plot, all trees 15.2 cm. (5 inches) d.b.h., and larger were tallied and recorded by species, diameter (d.b.h.), and total height. All ponderosa pines in each plot were classified as to green uninfested, year of attack, and pitchouts. Data were analyzed by a modified ADP timber sale cruise program. Results from this analysis provided input of tree and volume estimates by year which were entered into the PPSORT analysis to provide tree and volume loss estimates.

Results

Survey results show that the mountain pine beetle killed 109,284 trees with an estimated volume loss of 613,743 board feet of second-growth ponderosa pine on 1052.2 to 1214.1 ha. (2,600 to 3,000 acres) from 1970 to 1973 (table 1).

Table 1.--Estimated tree and volume loss estimates, Ninemile Ranger District, Lolo National Forest, 1970-1973

Year	Total trees killed	Total volume loss (board feet)
1970	50,836	331,651
1971	46,280	146,112
1972	9,048	106,860
1973	3,120	29,120
Total	109,284	613,743

The infestation declined steadily through 1973. Infested trees averaged 18.2 cm. (7.2 inches) d.b.h. in 1971, range 15.2 to 25.4 cm. (6-10 inches) d.b.h.; 19.3 cm. (7.6 inches) d.b.h., range 17.7 to 43.1 cm. (7-17 inches) d.b.h. in 1972; and 20.6 cm. (8.2 inches) d.b.h., range 12.7 to 101.6 cm. (5-40 inches) d.b.h. in 1973. An estimate of mortality and volume loss per acre is shown in table 2.

Table 2.--Estimated tree and volume losses/acre, Ninemile Ranger District, Lolo National Forest, Montana, 1971-1973

Year	Number of trees killed per acre		Volume loss per acre (board ft.)	
	Average	Range	Average	Range
1971	47.8	2-117	272	12 - 1,240
1972	25.2	1-152	140	1 - 360
1973	4.6	1- 23	39	7 - 167

Because PPSORT selects plots in proportion to number of faders, most plots fell in areas containing a majority of faders. To check equal probability selection, an additional twenty 0.20 ha. (½-acre) plots were randomly selected to survey. The majority of the stand in these plots showed only a few faded trees. However, random selection did select three plots that were previously surveyed. Results comparing number of infested trees/acre from the two surveys are shown in table 3.

Table 3.--Comparison of estimated infested trees/acre between random selection and PPSORT selection

Year infested	Random selection trees/acre	PPSORT selection trees/acre
1972	3.3 ± 38.9%	3.4 ± 27%
1973	2.6 ± 84.4%	1.2 ± 28%

Sampling error was higher on random selected plots than on plots selected by PPSORT.

Ground crews had no difficulty in finding the center of the 0.20 ha. (½-acre) circular plots using the 1:6,000 scale color photos. It took four men 2 hours to 100 percent cruise a 0.20 ha. (½-acre) plot. The two-stage survey proved to be an efficient method to estimate beetle losses. Interpretations were made on 2.38% of the area surveyed, and only 491.3 ha. (10 acres) or 0.38% of the area was actually cruised.

Douglasfir Tussock Moth Detection Survey Using Pheromone-Baited Sticky Traps - Steve Kohler

The recently identified and synthesized sex pheromone from female Douglasfir tussock moths shows a great deal of promise, as both a detection tool, and as a means assessing population densities in a given area. Work, concluded last fall, was very successful in determining the distribution of DFTM in the west through examination of pheromone-baited sticky traps for catches of male moths. Future work, aimed at relating catches of adult male moths to levels of larval populations in a given area, will be conducted and the results of this work will provide a means for early detection of population buildups and give land managers more lead time to plan control strategies, should an outbreak be unavoidable.

In the Montana detection survey, traps were placed at 125 locations throughout the entire host range (Douglasfir and spruce-true fir types) of Douglasfir tussock moth, Orgyia pseudotsugata (McDunnough), which included the western half of the State. Approximately 30 of the 125 locations were east of the Continental Divide. Traps were more concentrated in areas with a history of tussock moth activity.

Trap placement began July 27, 1975. All traps were in the field by August 20, 1975. Trap retrieval began September 15, 1975, and was completed September 29, 1975.

In the field, the traps were positioned on open grown Douglasfir or grand fir trees at least 10 feet tall. Two traps were placed at each location, on different trees at a minimum distance of 100 feet apart.

At least one adult male Douglasfir tussock moth was caught at 69 of the 125 total trapping locations. Results of the trapping show the distribution of Douglasfir tussock moth in Montana to be limited to the northwest portion of the State. This distribution includes the Flathead Valley, the Swan Valley, the Clark Fork River drainage from Rock Creek east of Missoula west to Idaho, the Blackfoot River drainage east from Missoula to Greenough, and the Bitterroot Valley south to Darby. No Douglasfir tussock moths were caught in traps east of the Continental Divide.

Four different species of tussock moths were caught in the traps: Douglasfir tussock moth, Orgyia pseudotsugata (McDunnough); western tussock moth, O. vetusta (Boisduval); rusty tussock moth, O. antiqua (Linnaeus); and a large grey-colored tussock moth, Paraorgyia sp.

A Different Approach to Doublasfir Tussock Moth Monitoring and Management - Tom Gregg

Tom Gregg opened the discussion by reviewing some of the Douglas-fir tussock moth population sampling problems encountered during the 1971-1974 outbreak in Oregon and Washington. He listed, in a general way, the sequence of events leading up to control decisions and discussed an alternative approach to population sampling and monitoring that could have resulted in more effective use of population data in justifying and supporting the needs for treatment in 1973 and 1974. It is hoped that significant improvements can be made the next time this insect becomes epidemic.

The approach outlined in Figure 1 is dependent on independent egg mass sampling with very limited larval sampling. This generally parallels the sample survey action taken during the past Douglas-fir tussock moth outbreaks in Region 6. Figure 2 outlines the alternative approach and emphasizes integrated population monitoring with intensive repeated larval surveys, supplemented with egg sampling as it becomes necessary.

In the past, many population sampling problems were created when surveys occur after considerable damage has taken place and a crisis has developed. Generally egg mass data has been used to delineate areas on maps where high population densities pose a threat to the forest resources. Control decisions then often

become difficult to justify when they are based on a limited amount of highly variable egg mass data. Periodically we will find outbreaks that appear, apparently over night, that will force management into this situation. Justification of control action will have to be based primarily on intensive egg mass survey data. This approach can be considered as an exception and not the general operating rule.

The alternative approach proposed ties together, in an organized manner, existing sampling methods designed to provide a variety of biological data, including tussock moth detection, population trends, larval and egg densities, egg viability, and virus incidence.

This approach to Douglasfir tussock moth surveys requires the development of no new sampling techniques, except possibly the use of pheromones for detecting and monitoring population changes. The proposal simply rearranges our survey priorities by placing emphasis on intensive larval surveys rather than egg mass sampling. It will allow time for the forest manager and entomologist to plan population monitoring surveys and take appropriate control action. It will result in greater statistical reliability and increased acceptance of survey results and control recommendation needs.

What is the problem with egg mass survey techniques? There are several egg mass sample survey methods that have been used during the recent outbreaks to evaluate the needs for control action. These include a multi-stage systematic plan (Mason 1970) and a sequential plan (Mason 1969). From an operational viewpoint, these two methods require an unacceptably large amount of sampling effort to achieve satisfactory results. Various modifications of these survey methods have been unsuccessfully tried by survey entomologists in an attempt to increase their effectiveness. The problem with egg mass sampling is the biological distribution of tussock moth eggs. This aggregation problem is common to many forest insect species, but is most acute in the case of Douglasfir tussock moth because of the extremely high number of eggs per egg mass. The number of eggs per mass commonly averages more than 200 during the release phase of an outbreak.

In 1970 Mason reported striking differences in the number of sample trees required to sample larvae and eggs at different levels of statistical precision. To sample a 1-acre universe with a population of 20 larvae or 20 eggs per 1,000 square inches of foliage, $\pm$ 20 percent standard error, $p = .68$; 12 trees are needed when sampling larvae compared with 60 trees when sampling eggs.

A review of Mason's (1969) sequential plans for classifying tussock moth egg and larval densities leads to the same conclusion. A considerably greater sampling effort is required to get satisfactory results from egg mass sampling than larvae sampling.

In light of the aggregation problem associated with sampling the egg stage of the Douglasfir tussock moth, it is hard to see how egg surveys can be effectively conducted in comparison with larval surveys. Egg mass surveys cannot reasonably provide an adequate independent data base, the kind needed by management to determine control needs for specific forested areas without a tremendous amount of effort and expense.

Since egg mass surveys provide essential estimates of egg densities, egg viability, and virus incidence, they will continue to be needed. These egg mass sample surveys can best meet management needs if used in a supportive manner within a comprehensive population monitoring program. This approach would allow optimum use of all entomological survey data in identifying high hazard areas and evaluating control needs. For example, once a new outbreak has been detected and the decision is not to control, then an intensive monitoring program can be started. From this point on, an outbreak area can be considered as an "Old Outbreak" (Figure 2). Time becomes available to plan and organize early instar larval surveys for the following June (July). Population densities and trends can be plotted on maps and hazard areas identified. Sample survey plots in areas apparently needing control can then be resampled (or sub-sampled) during the egg stage to determine egg densities, virus incidence, egg viability, and to verify population trends. If control action is again not indicated, existing larval plots can then be resampled the following summer. Additional areas can be added if the outbreak continues to develop in size. Likewise, areas can be dropped from intensive population monitoring if data indicates continued sampling is not needed. Current survey results can be added to the existing data base developed during previous sampling periods. Larval densities, population trends and other pertinent biological data can be plotted on updated maps. Areas having similar biological conditions can be post-stratified and analyzed stratistically to aid in the evaluation process.

This approach to Douglasfir tussock moth management is dependent on three important factors:

1. Having an adequate statistically designed early instar larval sampling method.

2. Having an adequate statistically acceptable means of evaluating population trends from early instar larval data.

3. Having an adequate detection program using pheromones or early instar monitoring plots.

Standard sample survey methods for estimating early instar larval densities have been described by Mason (1970). These methods for sampling trees and branches (branches in a 1:2 ratio) are adequate. There are, however, practical limitations associated with the Mason sampling scheme. It applies to measuring larval densities for a 1 acre universe. Mason points out that a change in this sampling design may be needed when surveys are planned for large areas. When these sample methods are combined with multi-stage survey techniques described by Hazard (1974), an efficient survey result can be achieved.

Early instar larval data collected during the recent outbreak in eastern Oregon and Washington strongly suggest that outbreaks can be predicted if larval densities are monitored during the release phase of an epidemic. Changes in population densities were observed by Mason in the general range of a 10 fold yearly increase from 1971 to 1973 in the Blue Mountain outbreak. Similar results were observed on Region 6 defoliator monitoring plots in the same areas during 1970 to 1973. The mean larval densities observed on the research population monitoring plots averaged 1.6 larvae per 1,000 square inches of foliage in 1971. Larval densities increased to 15 and 98 in 1972 and 1973, respectively. Population declines occurred in 1974. Paralleling this, Region 6 population data on the monitoring plots averaged 0.9 in 1970, 4.0 in 1971, 23.5 in 1972, and they exceeded 52.9 in 1973. Larval counts also indicated a decline in 1974. These results indicate that a significant increase in larval densities can be detected and the results effectively used in evaluating outbreak potential. In our view, we can afford to increase our sampling effort during the release phase of an outbreak to provide this kind of trend information.

The Douglasfir tussock moth monitoring program described above is dependent on an effective early detection system. Sample surveys using pheromones are presently being developed. This sampling technique has potential for early detection of tussock moth outbreaks and may provide a means for monitoring relatively low-level population trends. Region 6 defoliator monitoring plots using the 3-tree-beating method did provide valid information on the recent Blue Mountain outbreak. This technique is presently used for detection and monitoring relative changes in other forest insect pests in Canada and New Zealand.

This approach to Douglasfir tussock moth management as outlined in Figure 2 can go a long way toward providing statistically reliable data needed by forest managers and entomologists in making sound management decisions when dealing with this pest. This proposal emphasizes the need for early detection of tussock moth outbreaks followed up by an intensive larval monitoring program, supplemented by a limited amount of egg mass sampling as needed. If this approach to tussock moth management is adopted by pest management organizations, it could provide the following:

1. Early detection of tussock moth outbreaks before a crisis has been created.

2. A more effective and efficient means of coordinating existing larval and egg mass sampling procedures for evaluating Douglasfir tussock moth infestations.

3. A more effective evaluation of tussock moth populations and trends by utilizing data collected from all life stages of the insect. It would also provide a means of evaluating predators, parasites, and other biological control agents.

4. Timely information needed to justify control decisions before unacceptable losses occur.

5. Standardization of survey techniques which would allow direct comparison of data collected by various Regions, State organizations, and research stations.

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FIGURE 1

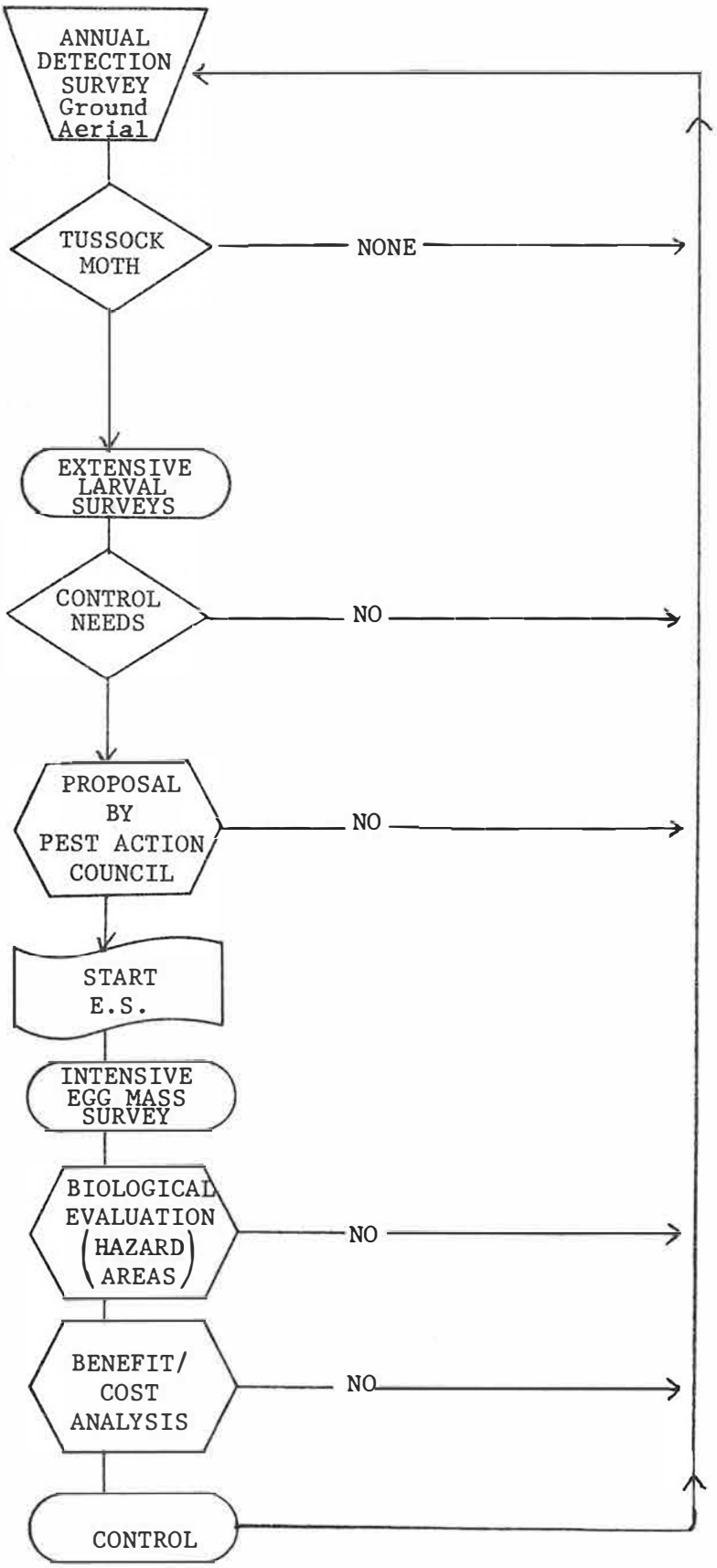
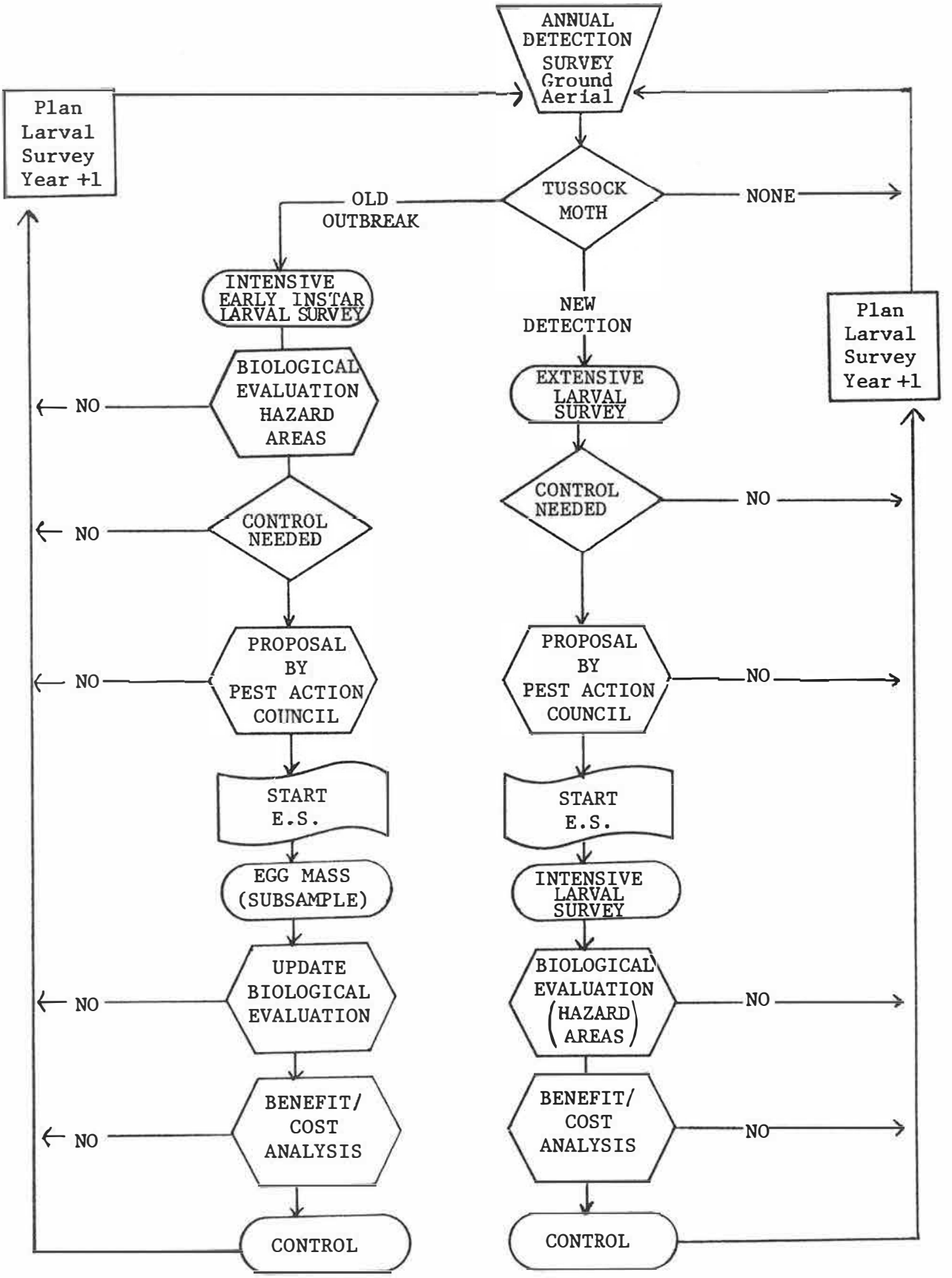

ANNUAL DETECTION SURVEY Ground Aerial
TUSSOCK MOTH
NONE
EXTENSIVE LARVAL SURVEYS
CONTROL NEEDS
NO
PROPOSAL BY PEST ACTION COUNCIL
NO
START E.S.
INTENSIVE EGG MASS SURVEY
BIOLOGICAL EVALUATION (HAZARD AREAS)
NO
BENEFIT/ COST ANALYSIS
NO
CONTROL

FIGURE 2


ANNUAL DETECTION SURVEY Ground Aerial
Plan Larval Survey Year +1
TUSSOCK MOTH
OLD OUTBREAK
NONE
INTENSIVE EARLY INSTAR LARVAL SURVEY
NEW DETECTION
Plan Larval Survey Year +1
BIOLOGICAL EVALUATION HAZARD AREAS
NO
EXTENSIVE LARVAL SURVEY
CONTROL NEEDED
NO
NO
CONTROL NEEDED
NO
PROPOSAL BY PEST ACTION COUNCIL
NO
PROPOSAL BY PEST ACTION COUNCIL
NO
START E.S.
START E.S.
EGG MASS (SUBSAMPLE)
INTENSIVE LARVAL SURVEY
UPDATE BIOLOGICAL EVALUATION
NO
BIOLOGICAL EVALUATION (HAZARD AREAS)
NO
BENEFIT/ COST ANALYSIS
NO
BENEFIT/ COST ANALYSIS
NO
CONTROL
CONTROL

WORKSHOP: BARK BEETLES - OPPORTUNITIES AND LIMITATIONS OF PHEROMONE USE

Moderator: Michael Atkins

Participants: Ronald Billings
Malcolm Furniss
John McLean
Gary Pitman
Lynn Rasmussen

During the past fifteen years, one or more workshops on bark beetle pheromones have been a trademark of the Western Forest Insect Work Conference. These workshops have not always been as productive as they might have been because of the potential of research in this area to lengthen publication records, generate financial support for research, and even result in the discovery of patentable compounds. If we are really honest with ourselves we must admit that there has been some withholding of information as opposed to the free exchange of ideas to which our conference is supposedly dedicated.

The suggested theme for this year's version of the pheromone story seemed to offer some potential for improvement. Consequently, I chose participants who I thought represented a cross section of experiences and approaches in the area of scolytid population manipulation in a variety of forest types. I then asked each participant to present recent discoveries, but rather than proclaiming successes, to concentrate on failures and some of the reasons for them. My reason for doing this was to attempt to stimulate a critical assessment of the current status of our ability to apply bark beetle pheromones as a means of determining where we should go from here and what pitfalls lie ahead. Frankly, I think I failed, but perhaps some of you will be more benevolent in your assessment. (M. Atkins)

1. Utilization of the Pheromone Sulcatol in Management of the Ambrosia Beetle Gnathotrichus sulcatus. (J. McLean)

   Sulcatol-baited traps have been used successfully in a sawmill situation to determine areas of greatest abundance, to monitor seasonal occurrence, and to reduce the level of attack on lumber by mass trapping.

   Ethanol baited traps did not catch significant numbers of G. sulcatus and ethanol did not enhance the attractiveness of

the sulcatol. Lumber in the immediate vicinity of sulcatol-baited traps received significantly more attacks than lumber further away, suggesting an area rather than focal point response by the male beetles.

Attack reduction was greatest during warm weather in July and August, but it was not determined whether this was due to host condition (relative dryness), increased sulcatol evaporation, or a combination of these factors.

Possible problems involve the ability of sulcatol-baited traps to compete with natural hosts and produce the desired level of attack suppression in the early part of the season. The high evaporation rate of sulcatol from traps during warm weather may lead to habituation.

Under the more natural conditions in the forest, vertical dead-trap configurations were superior to horizontal configurations, and sulcatol-baited host material was attacked both earlier and more heavily than unbaited material. Under forest conditions ethanol enhanced the attractiveness of the sulcatol necessitating a further examination of all the components involved in secondary attraction.

In a written report submitted by Dave Dyer there was an indication that frontalin only works effectively against spruce beetles on living spruce trees on which the attack is induced. At this time it is not possible to "dead-trap" spruce beetles in competition with naturally occurring host material such as windthrow and slash. This also suggests that more information is needed concerning the details of secondary attraction.

2. Management of Mountain Pine Beetle in Lodgepole Pine. (L. Rasmussen)

Beetles demonstrated a preference for larger diameter trees than trees less than 9 in. dbh. The preference of the beetle for larger trees often results in the utilization of thicker phloem and favorable brood production. When small diameter trees are attacked the success rate is about 2/3 of that in large diameter trees. If baits could be used to increase the attack on small, thin phloem trees, the resultant attack failure and poor brood to parent ratio should cause a substantial population reduction.

In addition, the manipulation of the chemical communication system of the mountain pine beetle should permit a reduction in the population through the disruption of mating, and trapping. It should also be possible to protect high-value trees by

attracting the beetles short distances to alternative host material. However, there seem to be behavioral differences that are not clearly understood, and it would appear to be better to exploit natural behavior than attempt to modify it. In this regard more research is needed to elucidate the relationship between host condition, beetle physiology, and the quality and quantity of pheromones produced under varying conditions.

3. The "Cut and Leave" Tactic of Pheromone Disruption for Southern Pine Beetle Control in East Texas. (R. Billings)

Since 1969, when large scale use of the insecticide BHC was discontinued, the strategy in east Texas for control of the southern pine beetle, Dendroctonus frontalis Zimm., has been to minimize timber losses from beetle attack by disrupting the natural expansion of individual infestations (spots). Although salvage of infested timber has been the primary and most recommended tactic employed, an alternative known as "cut and leave" has become increasingly adopted in situations where salvage is not feasible. The purpose of this presentation is to discuss the methodology, rationale, and efficacy of the "cut and leave" tactic of spot disruption.

Infestations of the southern pine beetle in east Texas can be quantitatively described by two phenomena: 1) the proliferation of new spots by dispersing beetles and 2) the expansion of established spots as beetles emerging within the spot are induced to attack trees on the spot periphery. Cut and leave is designed to disrupt the synchrony between emergence and pheromone production which is essential for natural spot expansion.

The tactic consists of falling all active trees (those under attack or containing bark beetle broods) towards the center of the spot. In addition, a 40 - 60' buffer of green uninfested trees also is felled to insure disruption of pheromone production. Once infested trees are on the ground, a certain portion of the developing broods are killed by adverse temperature and moisture conditions beneath the bark. More importantly, beetles that complete development and emerge from felled trees are no longer induced to attack on the spot periphery due to the absence of population aggregating pheromones. As a result, these beetles disperse out of the infested area.

In an attempt to assess the effectiveness of the "cut and leave" tactic on area-wide beetle populations, the Texas Forest Service is developing a post-suppression evaluation methodology which utilizes data from the state-wide computerized records of

detection and control operations. Briefly, we developed a computer program to quantify the temporal occurrence of new spots detected within a fixed area of each and every controlled and/or uncontrolled spot throughout the infestation area. The test of treatment effectiveness was based on the proportions of controlled (parent) spots having one or more new spots (proliferation) detected within approximately 1/2 mile (605 acres) subsequent to the date of control.

The analysis of spots controlled during the 1974 season revealed low levels of proliferation associated with spots controlled by both cut and leave and salvage applied during summer months (June - September). In contrast, high levels of proliferation were associated with spots controlled during the winter (October - December) as well as with uncontrolled spots remaining active into the winter.

These preliminary results suggest that beetle dispersal and proliferation of new spots is a seasonally dependent phenomenon, occurring primarily during the late fall to early spring. Spot expansion appears to be the most common mode of SPB infestation during the hot summer months. Accordingly, summer control by cut and leave (or salvage) appears to be effective for mechanically disrupting spot expansion as well as reducing the frequency of new spot proliferation. Analysis of the 1975 data is now in progress to substantiate these conclusions.

Finally, it should be recognized that the "cut and leave" tactic may not necessarily be as effective against the southern pine beetle in other regions of the south where the number of generations per year is fewer than seven and seasonal heterogeneity in attack behavior is not so prevalent.

4. Possibilities and Limitations of Bark Beetle Anti-Aggregation Pheromones. (M. Furniss)

The present knowledge of the occurrence of anti-aggregative pheromones for important species of bark beetles is summarized in Table I. There is a good probability that each bark beetle species has an anti-aggregative pheromone or a pheromone that otherwise terminates attraction. In one instance (Ips pini Say) an anti-aggregative pheromone (Ipsenol) is known, but the aggregative pheromone(s) remains unidentified.

TABLE I. ANTI-AGGREGATIVE PHEROMONES OF SCOLYTIDS

Species	Pheromone	Effectiveness
Douglas-fir Beetle	MCH	H
Spruce Beetle	MCH	M-H
Pine Engraver	Ipsenol	M-H
Western Pine Beetle	Verbenone	M-H
Southern Pine Beetle	Verbenone	M
Eastern Larch Beetle	MCH	M

Of the three strategies for which pheromones may be applicable (trap-out, confusion, exclusion), the exclusion strategy offers the best promise for protecting temporarily susceptible trees, until they either regain a higher level of resistance or, as in the case of windthrow, have deteriorated beyond a point where they can generate an increased beetle population. Furthermore, the anti-aggregative pheromone, MCH, has been shown in field tests to be less disruptive of an important predaceous clerid, Thanasimus undatulus Say.

In 1972, field tests of liquid MCH were conducted to determine the optimum concentration and spacing for prevention of infestation of susceptible felled trees by the Douglas-fir beetle. In 1975, controlled release granular formulations of MCH were tested and compared to the liquid standard (MCH eluted from 1/2-dram vials located on 4' high stakes at 10' x 10' intervals around felled trees) and untreated controls. The effects of the treatments varied greatly, but some of the controlled release formulations were effective in reducing beetle attack density, as shown in Table II. Of particular interest is the variation in attack density when one of the formulations (No. 1) was applied from stakes at 10' intervals (simulating the liquid standard) and broadcast on the ground at two rates.

TABLE II

EFFECTIVENESS OF CONTROLLED-RELEASE FORMULATIONS OF MCH. 1975.

Treatment	Method	Douglas-fir Attacks	Beetle Brood
		Average No. per square ft.[4/]	
Formula 1[1/]	P	.1**	1**
Standard	P	.2**	4**
Formula 4	B	.3*	33NS
Formula 3	B	.4*	7**
Formula 5	B	.6*	26NS
Formula 1[2/]	B	1.7NS	51NS
Formula 1[3/]	B	3.5NS	42NS
Control	___	4.8	45
Formula	B	4.9NS	54NS

1/ Set out to simulate standard in amount and spacing.

2/ Broadcast at standard rate.

3/ Broadcast at 1/10 standard rate.

4/ Basis: 6, 12" x 12" bark samples/replicate.

The amount of Douglas-fir beetle brood produced in the treated trees was significantly reduced by some of the treatments, but was found to be highly variable for formulation No. 4.

The more effective controlled release formulations will be tested against windfelled Douglas-fir rather than trees felled by cutting. Windthrown trees may have greater resistance to low attack densities by the beetle, thereby reducing further the amount of brood produced in them. If controlled release formulations of MCH can be developed that are effective in preventing the increase in beetle populations in damaged trees, it may be possible to maintain the infestation at an endemic level by forcing beetles to attack more resistant trees which do not normally generate outbreaks.

5. A Douglas-fir Beetle Management Strategy Using Pheromones and Kairomones. (G. Pitman)

Table I presents a summary of a management program for the Douglas-fir beetle in the Inland Empire which is based on the use of a combination of pheromones (Douglure) and Kairomones (= anti-aggregation pheromones) (Dougaway) in damage prevention and population suppression. Most of the tactics have been used in pilot tests and have proved to be viable. However, there are several areas where more work is needed.

TABLE I. DOUGLAS-FIR BEETLE MANAGEMENT STRATEGY USING PHEROMONES AND KAIROMONES. (G. PITMAN)

Situation	Objective	Tactic	Remarks
Pest maintenance Low population levels	Preventive maintenance	Preharvest baiting with Douglure	Logging must be completed same year as baiting.
	As above	Road and strip baiting with Douglure	As above
	As above	Treatment of susceptible trees, right-of-way, landing, storm damage, etc., with Dougaway.	Follow-up same year as baiting not necessary, but trees should be harvested as soon as possible.
Pest suppression High population levels	Salvage logging	Preharvest baiting with Douglure	Logging follow-up required.
	As above	Road and strip baiting with Douglure to increase efficiency.	As above
	Pest containment	Aerial application of Douglure on infestation centers (spots).	A holding action to reduce pest dispersion until logging can be carried out.
	Pest Dispersion	Aerial application of Dougaway on infestation centers.	Breaks up spot infestation and results in increased dispersion mortality.
	Population pest sinks	Live-tree baiting with a combination of Douglure and Dougaway	Results in attack patterns that are non-lethal to the tree and thereby increase insect mortality.

The breaking up of "hot spots" through the aerial application of Dougaway should increase dispersion and in-flight mortality. However, the full consequences of this tactic are not known. Although some increase in mortality seems likely, it needs to be quantified. Whether the dispersed population initiates new population centers in the adjacent stand also needs to be evaluated.

A combination of attractant and attractant inhibitor applied to trees from the ground significantly increased the occurrence of pitchouts over control plots or plots treated with attractant alone. However, when the combined treatment was made aerially only a partial success was obtained. The problem probably involves relative concentration of the attractant and inhibitor, but additional experimentation should lead to the establishment of the optimum ratio.

Once the nature and effect of scolytid behavior-mediating chemicals are known the development of overall population management strategies for a number of scolytid pest seems well within the realm of possibility.

SUMMARY. (M. Atkins)

On the basis of a review of the ideas presented during this workshop and the content of a number of general discussions I was involved in before and after the workshop, I attempted to identify some shortfalls. I perceive three areas that would seem to be of substantial importance to the successful manipulation of bark beetles by way of chemical communication that have been neglected or at least inadequately investigated. These are, in my view, host physiology, population behavior, and biometeorology. I am not a plant physiologist so will not comment on host physiology beyond saying we clearly need more information. However, I will take this opportunity to once again comment on the other two areas.

POPULATION BEHAVIOR. We still do not have an adequate understanding of bark beetle population behavior in general and their dispersal process in particular. Bark beetles are classic examples of r-strategists; i.e., they are opportunistic colonizers of transitory environments with the capacity to multiply rapidly in the presence of abundant resources. By definition r-strategists are programmed to migrate sometime in their life history in order to keep pace with changes in the distribution of needed resources. Bark beetles are no exception — they emerge and leave their old breeding site before oogenesis if they are physiologically capable. Their migratory capacity varies from individual to individual according to each's physiological condition (a reflection of the genetic and developmental history).

It is possible to demonstrate this behavioral or physiological variability. As most of you know I found a correlation between behavior and fat content, and others have since substantiated those findings. At this point it is just a correlation and we are far from establishing any causal relationships, even though it seems to be a common occurrence among scolytids. But regardless of the physiological and behavioral variability in a population of r-strategists, the overriding behavior is to leave the old breeding site. The kind of flight behavior displayed by newly emerged bark beetles is illustrative of many migrants — i.e., upward spiralling followed by leveling off above the canopy and a "straight track" flight down wind. It is typical of migrants not to be responsive to appetitive stimuli nor to break off their flight to engage in feeding or reproduction. These appetites are indulged only after the migratory drive has been satisfied. The initial flight behavior — towering — carries the migrants beyond the relatively still air beneath the canopy where odor plumes are readily detected, into the zone of horizontal circulation above the canopy where odor is unlikely to provide much navigational assistance.

Once migratory flight has been terminated, the behavior of the individuals becomes dominated by trivial flight — in the case of bark beetles below the canopy. During this period we encounter flights into the wind and responses to appetitive stimuli. When we sample populations in an infested area with rotating nets, we do not know the behavioral composition of the captured sample. When we sample with an olfactometer, we catch responders only and gain no information about the size of the migrant population. The failure of attractant-baited traps to capture young migrant individuals has been reported for a number of insects.

Many migrants display patterns of adaptive behavior that assure migratory success. This often involves periodicity of flight activity or a responsiveness to some specific non-host stimulus such as the plane of polarized light needed as a navigational aid across open space. Perhaps if we could identify some of these key elements in the behavior of bark beetles that are not part of their chemical communication system, we would have a better chance of both evaluating populations and manipulating populations.

In summary, I do not see how we can develop a general concept of how best to use either attractants or dispersants with some predictability as to the outcome, unless we make an effort to learn more about the behavioral makeup of populations that develop at different times under different conditions.

BIOMETEOROLOGY. Good bioclimatic studies invariably contribute to the solution of insect pest problems. Yet there seems to have been a lack of interest in this area among bark beetle biologists in recent years.

There has been much written on the effects of drought, frost, windfall, etc. on the availability of suitable host material. There has been quite a bit done on the conditions, particularly temperature, that bracket certain biological functions of the beetles or influence their survival over winter. But there is a dearth of information on even the gross effects of weather on bark beetle migration and chemical communication. For example, what is the effect of temperature and humidity on the life of pheromones, or the ability of individuals to produce or perceive them? What effect does the weather have on the production of precursors, synergists, or inhibitors by the host trees? Are different trees more or less attractive under certain transitory weather conditions? Does a process like steam distillation contribute to an enhancement of host recognition if high temperatures follow rain?

I think that both in the area of population behavior and the bioclimatology of chemical communication there are countless questions that still need to be answered. The key of course is asking the right questions. Nevertheless, there seem to still be many opportunities for exciting research, the results of which should have considerable practical significance.

WORKSHOP: SEQUENTIAL SAMPLING--DOES IT WORK FOR FOREST DEFOLIATORS?
Moderator: Douglas L. Parker
Discussion Leaders: Robert E. Acciavatti, Tommy Gregg, Richard R. Mason, Melvin E. McKnight, Roy F. Shepherd

Even though sequential sampling has been discussed many times during past work conferences, and promoted by several research workers, there has been little discussion of the practical application of this sampling method. The primary purpose of our workshop was to bring research and survey entomologists together to discuss the practical uses of sequential sampling techniques of defoliators such as the western spruce budworm (McKnight et al. 1970) and Douglas-fir tussock moth (Mason 1969).

Following tradition at our workshop, a small and discriminating group of entomologists informally discussed sequential sampling. Comments were to the point (some were out in left field), tempers flared once or twice, a few people left early, and misconceptions were identified; but several of us gained valuable information that we can put to use.

Doug Parker opened the workshop by summarizing the use of published sequential sampling plans by survey entomologists. He obtained the information by canvasing survey entomologists and reviewing biological evaluations. Doug found that 14 published plans had been developed after Waters (1955) supplied a basic reference on sequential sampling. Of the 14 plans, only two were used to any extent: McKnight's plan for western budworm egg mass surveys, and Mason's plan for sampling egg and larvae of the Douglas-fir tussock moth. None of the other plans apparently were being used at present. The reasons mentioned by survey entomologists for not using the various sequential sampling plans follow:

1. The original purpose of the plan did not conform with current survey objectives. For example, Knight's (1960) plan for identifying increasing populations of the mountain pine beetle in ponderosa pine to determine if treatment was necessary did not conform with current needs. Entomologists said they would rather wait and measure infested trees.

2. Even though the greatest advantage of the method lies in the saving of sampling effort and time, compared with fixed sampling approaches, many of the published plans required too much sampling effort to be used.

3. Some felt the plans were based on data collected during too short a time frame in regard to a population cycle.

4. One or two entomologists were skeptical about using sequential sampling after being advised by a statistician not to use it.

5. Many entomologists were not familiar enough with the method to use it.

Bob Acciavatti and Mel McKnight then led a discussion on a "Sequential Plan for Western Budworm Egg Mass Surveys in the Central and Southern Rocky Mountains." Bob commented on the efficiency of sampling and raised questions on some assumptions in the plan. Bob stated that the sampling approach was not efficient; twice as many branches as minimally required had to be collected on the first field collection, and a second field collection trip would be necessary when there were intermediate populations and further sampling was needed. In regard to assumptions in the plan, infestation classes were developed from new egg masses per 1,000 square inches of foliage from half branches. McKnight (1968) found that new egg mass densities (per 100 square inches) did not differ between half branches and 24-inch branches. He estimated that 24-inch branches had 250 square inches of foliage, which is one-fourth of what was used to develop the plan. Bob felt this was not valid, and it would be better to measure a branch and then calculate the egg density per 1,000 square inches. Secondly, current year's defoliation is developed from counting shoots; however, defoliation prediction for the next year is based on field-glass estimates for whole trees. The two are not always comparable. Finally, data used in development of the plan were obtained from "static" infestations and may not apply to "increasing" infestations.

Next, Tommy Gregg discussed the sampling techniques used during the recent Douglas-fir tussock moth outbreak in the Pacific Northwest. He explained the planning process and the reasons for using a fixed-tree sampling design.

Dick Mason mentioned that there may be some misunderstanding in the group. He emphasized that sequential sampling is a technique to measure numbers of insects--whether they be eggs, larvae, etc.--at a given location and time. When predicted defoliation or any other related factors was presented, this went beyond sequential sampling as such, and other factors have to be considered in interpreting the data. He also stated that the technique was reliable for sampling numbers of insects, and that it was relatively easy to develop if one had the basic information for a given insect.

Rick Johnsey took a few minutes to discuss how he had used Mason's (1969) plan on an evaluation he had conducted in Washington. He had modified the plan to suit his needs, and felt he had excellent success.

Roy Shepherd then presented a means of estimating the number of samples used in sequential sampling in relation to confidence limits desired. He said the information presented by Iwao (1968) and Iwao and Kuno (1968) had not received much use in forest entomology in the western United States and Canada. Copies of the two papers were sent to interested participants.

The moderator concluded the workshop by stating that he thought that some touchy points had been discussed, and he hoped no feelings were hurt, and felt that participants had exchanged some useful information

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HOW TO MEASURE IMPACT OF DEFOLIATORS

Moderator: Wayne Bousfield

Participants: John Wear and John Wortendyke

Measuring impact of defoliators can be complicated because they affect the tree in terms of growth loss, top kill, mortality, and competitive position in the stand. We will direct our attention on measurements one can take to evaluate impact on host trees and techniques of surveying large areas of an infestation.

Radial growth is a measurement most commonly taken to determine growth loss and the following research by (Carroll Williams 1967) shows effect of radial growth on grand fir in eastern Oregon following a spruce budworm infestation.

Average Radial Increment of Grand Fir Trees by Damage Class

Damage class	Number trees	Average pre-outbreak period 1935-45 mm	Average outbreak period growth 1946-56 mm	Adjusted[1/] average outbreak period growth mm
I	10	3.96	2.91	2.55
II	14	2.56	1.95	2.12
III	11	2.89	1.73	1.77
IV	12	2.87	1.68	1.74

In his paper he pointed out that the greatest losses occurred in the upper crown area; however, at d.b.h., growth loss could be detected.

Radial growth is not a linear relationship, however, predicted diameters can be obtained when the past 10-year growth is known by applying the following formula developed for R-1 Timber Management Group by Al Stage, Intermountain Station at Moscow, Idaho.

$$D1 = \sqrt{D^2 + \frac{(2D - di)(di)}{10}}$$

Where D1 = Diameter one year from now.
D = Present diameter
di = 10-year diameter increment

1/ Average damage growth minus deviation from experimental average multiplied by error regression coefficient. Adjusted averages are significantly different at the 5 percent level.

Regression analysis may also be applied to measure radial growth loss in certain cases. One opportunity occurred in 1973 when the tussock moth infested Douglas-fir stands on the Nezperce National Forest in Idaho. In this case the areas of defoliation had sharply defined margins and an opportunity existed to have control stands adjacent to defoliated stands.

Covariance analysis was employed to test difference or adjusted width of 1974 and 1975 growth rings. The four years growth prior to defoliation of each tree was used as the independent variable in the regression, and the last two years the dependent variable. Ring development in 1973 was completed by August when severe defoliation occurred and was not thought to be affected, and considered normal. The following table shows the results of the analysis.

Regression coefficients tested by Covariance Analysis

Covariance Analysis of Increment Core Measurements

Area	Regressions Coefficient	"F" Value	Adjusted Means1/	"F" Value
Lucile Defoliation	.122	4.12	.061	5.96
Lucile Check	.299		.088	
Race Cr. Defoliation	.135	28.03	.049	12.87
Race Cr. Check	.410		.071	

Mortality and top kill can be obtained by using ordinary cruising techniques which will give you volume and trees per acre by damage class. Usually damage classes from 0 - 6 can be used to code each tree and standard cruise programs will give you volume and trees per acre by damage class.

Forest Insect and Disease Management, Region 6, is deeply involved in two forest insect defoliator impact surveys; a Douglas-fir Tussock Moth Impact Survey started in 1973 to be concluded in 1978, and a Western Spruce Budworm Impact Survey to start in 1976 (already covering one to seven years of successive defoliation) and to continue through 1980.

The key objective of the DFTM Impact Survey was to determine the volume and growth impact in host stands in each defoliation damage intensity class (not impact estimates for the total area of concern).

1/ Width of 1974 and 1975 growth ring adjusted by covariance analysis.

A multi-stage sampling design, double-sampling for stratification, was implemented in 1973 to estimate long and short-range effects of defoliation in the Blue Mountains of eastern Oregon and Washington. The survey was extended to the Colville Indian Reservation and Halfway areas of Washington and Oregon, respectively in 1974.

Sixteen 6-mile photo strips were established in the Blue Mountains (1973), and five 3-mile and eight 3-mile photo strips were selected in the Halfway and Colville Indian Reservation areas respectively (1974). A systematic grid distribution of 1-acre photo plots (12 per mile) was made for each flight line (plot centers transferred from quadrangle maps and scale of each plot determined before scribing on the 1:4000 scale color infrared transparencies). All 1-acre photo plots were interpreted and stratified into five damage intensity classes. Ground plots were selected by allocation proportional to the total plots in each intensity class. An average of 13 ground plots per photo strip was selected in the Blue Mountains, 6 in Halfway, and 7 in the Colville Indian Reservation.

Operational survey constraints for conducting sequential aerial photographic surveys were discussed. This included contracting vs. in-house field work, quality control for field work, survey efficiency (time, costs, manpower, and accuracy standards), and the problems of obtaining high quality sequential aerial photography.

The WSBW Impact Survey for 1976 is complex because of the proposed control operation on approximately 300,000 acres of major infestations in host type. Survey objectives include determining treatment effectiveness, estimating impact on understory and overstory stands, estimating impact on fire management and recreation management, and determining the feasibility of aerial photography to estimate volume in various damage classes.

Four different survey designs have been developed for operational consideration to meet survey objectives. Statistical rationale, cost factors (manpower, time, and efficiency), and logistics of implementing the survey are outlined.

A. Double-sampling for stratification (combination of field and photo plots)

1. 2-mile photo strips, 1:3000 scale, color infrared film.

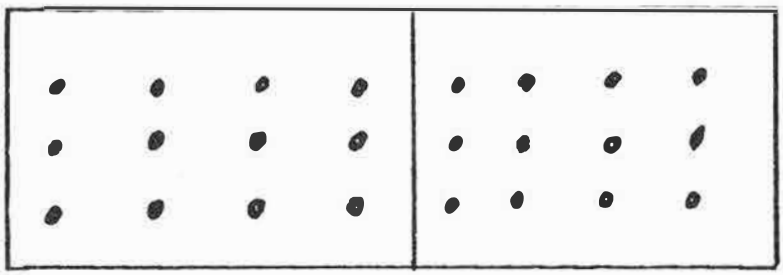
a. 4 random photo strips per stratum (0, 1-2, 3-4, 5-6 years of defoliation in treated and untreated zones), 7 strata (no treatment in 0 class). Total photo strips 28.

b. 12 photo plots/mile on systematic grid (10 chains x 20 chains). Total photo plots 672.

c. 4 ground plots randomly selected from 12 photo plots, 1-acre plots with 4 prism points, #20 and #5 BAF prisms, 224 total ground plots.

d. 2-man crew, 2 plots per day, 112 crew days, 5 crews 21 days, $100.00 per field plot.

2-mile Photo Strip



2. 40-acre photo plot

a. 6 strata (0, 1-2, 3-4, 5-6 years of defoliation in treated and untreated), no 0 treated class and no 5-6 untreated class.

b. 10 40-acre photo plots per stratum, total 60.

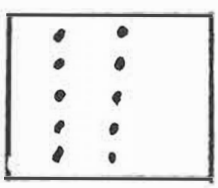
c. 10 1-acre photo subplots per 40-acre plot, total 600.

d. 4 random 1-acre ground subplots per 40-acre plot, total 240.

e. 4 prism points per 1-acre subplot, #20 and #5 BAF prisms for overstory and understory measurements.

f. 2-man crew, 2 ground subplots per day, 120 crew days, 6 crews 20 days, $400,00 per field plot.

40-acre Photo Plot



10 1-acre subplots
4 prism points per subplot
(#20 and #5 BAF prisms)

B. Ground survey

1. 10-acre plots

a. 6 strata (0, 3, 4, 5+ years of defoliation, treated and untreated), no 0 treated class no 5+ untreated class.

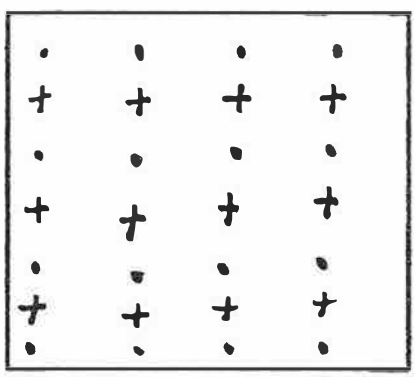
b. 20 10-acre plots per stratum, distributed with allocation proportional to size of stratum, total 120.

c. 12 prism points (#20 BAF) per 10-acre plot.

d. 28 1/100 acre fixed radius (11') understory plots.

e. 2-man crew, 2 days per plot, 240 crew days, 10 crews 24 days, $400.00 per 10-acre plot.

10-acre Plot



\+ #20 BAF prism points (12)

• 1/100 acre fixed radius plots (28)

2. 2-acre plots

a. 6 strata (0, 3, 4, 5+ years of defoliation, treated and untreated), no 0 class treated, no 5+ class untreated.

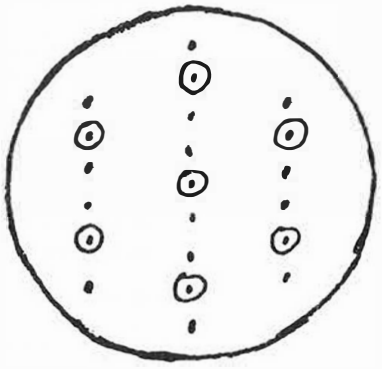
b. 40 2-acre plots per stratum, total 240.

c. 7 prism points (#20 BAF) per plot.

d. 21 1/400 acre fixed radius (6') understory plots.

e. 3-man crew, 1 day per plot, 240 crew days, 6 crews 40 days, $250.00 per field plot.

2-acre Plot



#20 BAF prism points (7)

1/400 acre fixed radius plots (21)
3 lines 1½ chains apart
Plots ½ chain apart

A multi-stage sampling or straight ground survey to measure impact of defoliator outbreaks should be planned to efficiently use money and manpower resources in relation to desired sampling errors and probabilities. Questions as to number and size of plots, sampling units per plot, etc. have been difficult to answer. Generally, "educated guesses" have been relied upon to determine plot numbers in the past. Consequently, survey data may be either more expensive than necessary, or statistically weak for the effort expended.

A computer program developed by John Hazard and Larry Stewart of the PNW Research Station can determine the optimum number of plots and subplots (up to 3 levels) provided population variances and cost factors are known. The program, titled MUST, is easy and inexpensive to use. A description of the program, options, and procedures are detailed in "Planning and Processing Multi-Stage Samples with a Computer Program--MUST" by John Hazard and Larry Stewart, USDA Forest Service, PNW-11, (1974).

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HOW DO WE PUT TECHNOLOGY TO WORK?

Moderator: William M. Ciesla

Panel Members: Louise Parker, Bob Campbell, Jim Krygier, Duane Thurman

Approximately 15 people attended. Those asked to make presentations are listed above. Discussion was centered on the following questions:

1. What is technology transfer?
2. What are some mechanisms of technology transfer?
3. Within your individual experiences, what are some good examples of research results that have been put to work; some poor examples?
4. When should emphasis be switched from a full scale research effort to a technology transfer effort?

Louise Parker, Information Specialist, PNW

Important Points to Get Across

1. Now is an especially important time to improve our methods for technology transfer. It is a time of reduced budgets, and a time of tightening up in the research organization. Just as we need to find better, more efficient ways of doing the research job...so we need better, more efficient ways of doing the job of technology transfer.

There has been a lot of waste here in the past: reports published without a clear purpose, or a coherent idea of a specific audience, without involving the audience. Also, cases where information was badly needed, available from research, but not packaged in ways that would be helpful to the user. This has got to stop... we simply have got to do a more planned, organized job of dissemination of research information. We need to put our money where the priorities are.

2. Technology transfer, and communication techniques, need to be integrated into the whole research planning process.

3. The "package" approach to information dissemination means reprocessing the information for different audiences.

4. There is a need to separate scientific and very technical publications from "technology transfer". Scientific publication

is the original documentation of research results; it has the scientist as the principal audience. This kind of material may be of interest to some forest resource managers -- but damn few, probably only the early adopters. But this can and must serve as a basis for the technology transfer or "packaging" effort.

5. Technology transfer needs to be a full partnership between:

   a. The scientist and research administrator
   b. The forest resource manager, or specialist in land management.
   c. Information specialists

TECHNOLOGY TRANSFER

A. What is Technology Transfer?

Nothing more than the communication of information gained from research to potential users. Notice I said communication.... which is more than relating the information. I like one of Webster's definitions of communication..."a process by which meanings are exchanged between individuals." This implies that communication is more than just the transfer of words from one person to another. It implies an understanding, or real communication, of the information, so that the user ends up not only with the same set of facts, data, etc., but that the information is interpreted in the same way.

For example, the research fact may be that tussock moth outbreaks tend to follow a predictable three-year cycle. The researcher has implied in this statement (for himself) that control efforts should be undertaken before the 3rd year of the cycle. But he may not have made that clear. The resource manager hears this, but he adds an interpretation of his own -- that is, the objective not only of keeping the outbreak from spreading during the 4th and 5th years...but of saving trees from defoliation during the 3rd year. In this case, the researcher might have anticipated this question from the forest manager, and added his own observations about the effect of insect control efforts in saving trees during the 3rd year of an outbreak.

B. Mechanisms for Technology Transfer

There are as many as there are communication techniques:
Word of mouth
Publication -- the written word
Audio visual -- motion pictures, video tape, slide talks
Handbooks, "how-to" guides

Articles in trade journals or magazines
Summary publications
The scientific publication or technical journal article
Bibliographies
Better library services: PACFORNET
Extension workshops, seminars, special classes
Demonstration projects: self guided tours
Newsletters
Mass media: newspaper, television
Etc.

C. Good and Bad Examples of Technology Transfer

Good Examples:

1. Forest genetics research: almost immediate application of research results, principally by the researchers working directly with the users, and having a small, very specialized audience: managers of seed orchards, forest nurseries, etc.

2. The 3-year cycle for tussock moth outbreaks: people may not agree about the exact time frame, but there are not many, either in the profession or out, that don't know that tussock moth outbreaks are cyclic, and that they are likely to collapse after several years! Transfer of technical information resulted because of a high degree of interest in the subject matter... and because this point became a focal one in terms of EPA's making a decision about the use of DDT in 1973.

3. Fall, Buck, and Scale Cruising: almost immediate application by BLM of a technique which they helped develop. As I recall, the idea dame from BLM, but the details were worked out with the help of Floyd Johnson, PNW. By the time the Station got around to thinking that a field guide would be a good idea, BLM already had it done and was using it! That's a technology transfer.

4. Sawmill Improvement Program: a cooperative effort nationally of S&PF and Extension Service, and the Forest Products Laboratory -- a concerned effort to get across improved milling practices that is being very successful right now. They're putting dollars into it. Also there is a strong incentive for the mill to improve once they see how new systems can help. They'll make money on it!

5. COM-PLY: a new composite building material that uses residues for primary building construction -- studs, flooring, siding.

6. Incentive System for Litter Control: a recreation research unit has worked with iorest managers to get them to adopt the incentive system for litter control. Used extension techniques

working with guys in the field, local forest workshops with demonstrations, slide talks, etc.

Keys to success:

a. The idea or techniques need to be viable, timely, useful
b. The information has to be communicated
c. The incentive for change on the part of the user needs to be apparent
d. Good principles of communication need to be used

All technology transfer involves CHANGE, new and better ways of doing thins...which often implies that the old ways are not the best.

Bad examples:

Early forest scientist Leo Isaac in this region indicated that Douglas-fir could be regenerated under partial shade. Yet for many years clear-cutting was thought to be the only way to grow Douglas-fir. It's the sunlight, foresters said! And, when foresters started getting poor results in places like southwest Oregon, they still persisted! We just aren't clearcutting right, they decided. Finally, other methods were sought, and today BLM, for example, has almost entirely gone to a shelterwood harvest in that region.

C. When Should the Emphasis Shift from Research to Technology Transfer?

I'm not sure this is the point; the point is that technology transfer needs to be integrated into the whole research planning, execution, and development process, and into what would normally be thought of as a standard public information program.

1. Research planning: the scientist and administrator design the research, decide what problem needs solving and who needs help. It is at this point that communicators should begin working with scientists to plan the extension program. Need to determine who is the audience for the information and how best it can be communicated.

2. During the Research: information can be released telling the user what is happening, that the research is being initiated, getting him interested and involved in the effort, show-me trips can be planned, and the stage set for later transfer of the research results. I think this is a very important phase...it gets the user interested, and helps him anticipate that change is in the mill. It's psychologically good business.

**Here's an example. One morning you wake up, a little earlier than usual, your wife is nudgin you in the ribs, and she says: well, today's the day! There's going to be some changes around here. I'm tired of doing dishes all the time. We're getting a dishwasher! Now. Today.

Well, you've been planning to spend that money on new tires. The whole idea hits you cold, and you're instantly negative. You're forced to change too quickly. It doesn't give you time to get geared up...to save some money...think about it a while... plan where to install it, and how...to get used to the idea of changing. Besides you'd probably be more receptive if it had been your idea in the first place. Well...no wife in her right mind would handle a situation this way, at least not more than once. If you think about how she could have handled it... you'll probably learn something about technology transfer.**

3. Research is Wrapped Up: so what happens then, now that the research is pretty well wrapped up, you have some results, and you're ready to really tell people what you did.

Packaging of Research Information: use all suitable communication techniques to get the information to the variety of people that need it.

a. Usually there is more than one audience, i.e.

Forest resource managers - the people that need the information to do the work
Resource administrators - the people who make decisions about new programs or money spending
General public - the people that pay the bill and need to be kept informed about new and better ways of doing business
Legislators - occasionally need to be informed of specific research information, for example during the tussock moth crisis, in legislation concerning clearcutting, etc.
Conservation organizations - become involved in public issues
Probably others.

b. The communication techniques, and degree of information needed differ for each audience. The result: a "package" of informational materials, or techniques, designed to reach the people that need the information.

D. What Then?

You may think the job is over, but it is not. At this point,

there comes what is both the final phase of technology transfer, and the beginning. The need for feedback...and for closing the circle and tying the end into the beginning again. We've already recognized that change is never-ending. Nothing remains the same forever. The system is going to change, the methods improve. It's just a matter of time.

Now when the research is completed, and the technology transfer process is in full swing...it is very important to have feedback ...from the user of the research information. The system is being put into effect. How well is it working? Does it need adaptation? Should more DEVELOPMENT work be done? The lines of communication between the research organization and the forest resource manager are extremely important now. And so feedback again leads to change...perhaps to new research programs...and the cycle continues.

Robert W. Campbell, Research Entomologist, PNW

1. The phrase Technology Transfer doesn't seem to be well defined. Thus it probably means different things to different people.

2. If Technology Transfer is roughly equivalent to Exchange of Information, then it seems clear that both "hard information", such as regression equations, and "soft information", such as general impressions, can be exchanged.

3. A publication titled The Gypsy Moth and its Natural Enemies was cited as an example of "soft information", and copies of this publication were distributed. Also some background was described on the events that led to the preparation of the manuscript in the first place.

4. Subsequent discussion of the above publication revealed that many of the research scientists at the workshop believed that this sort of publication will not help the scientists career and might even "count against you." This question, unfortunately, had to be left unresolved.

D.E. Thurman, Union Carbide Corporation

One possible definition of technology transfer is the orderly development and dissemination of the scientific data necessary to create understanding in others and achieve the desired objectives. Proper communication of objectives, standards, and measures of performance are critical to successful team efforts. Most large chemical corporations are heavily matrixed and have peer managers in many different functions such as sales, marketing, market development, research production, distribution, accounting, law and employee relations. The goals and performance of these individual functions must mesh if the organization is to operate as a profitable entity. Communication to create understanding and coordinated progress is an important process in managing a matrix organization. The process of information transfer or dissemination alone is not sufficient to insure technology transfer. A chemical company survives and grows in profitability only if both its technology and technology transfer are superior to its competition.

The development of a new experimental pesticide is a good illustration of ways in which technology transfer can and must be put to work successfully. This development process involves a complex communications feedback loop which ties together scientists and other personnel in exploratory synthesis, biological screening, field research, toxicology, residue and metabolism, chemistry, patent law, process development chemistry, formulations, engineering, marketing, government regulatory affairs, and finally production and sales. Numerous decision making checkpoints are necessary over a 4 to 7 year period to ensure completion of the development process. Responsible managers must receive on time the necessary data and understand fully the technology developing simultaneously in each of these different research areas.

This development process can easily be related to large Forest Service programs such as the expanded DFTM project. Again, personnel in various scientific disciplines and functions must understand the overall objective and how their individual objectives interlock. Likewise, new technology being generated must be timely communicated to other functions and managers or the project may fail to neet its goals and timetable.

WHAT POPULATION MODELS CAN DO FOR US

Moderator: Walter E. Cole

This was an informal workshop without any solicited papers. However, certain individuals were primed to contribute their philosophies and pertinent results to the discussion. The following comments are not necessarily those of the moderator, nor of those of the participants; just tidbits of knowledge and gems of wisdom gleaned from a sometime high level conversation, and at other times, not so high level.

The need for use of models is in strategic rather than in tactical thinking.

The term modelling is used in so many confusing ways in various fields that it is not always obvious which is model and which is mimic.

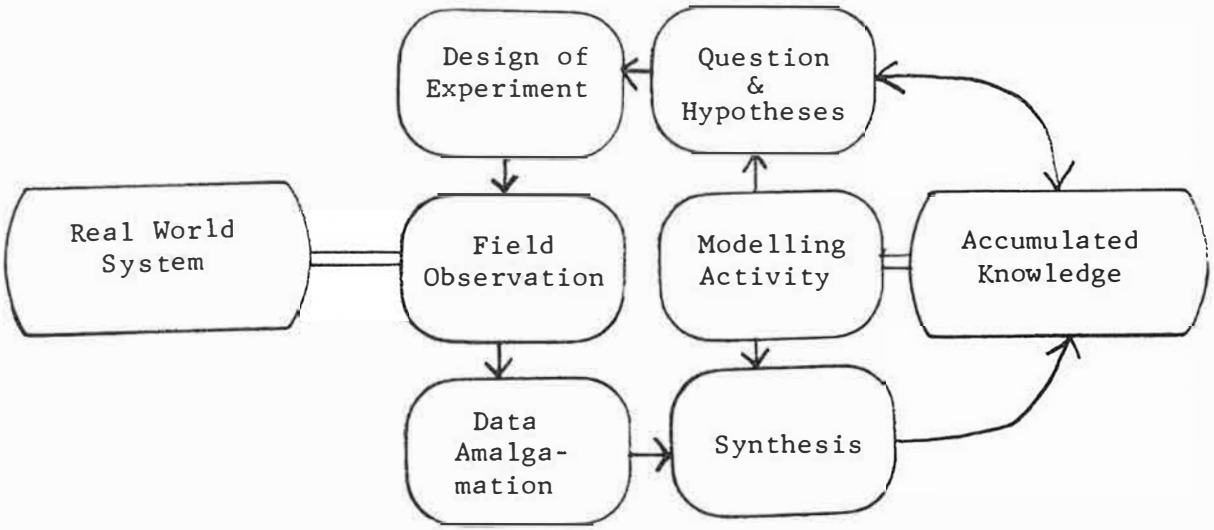
Why Model and Is It Feasible?--What can we hope to obtain from a model of one situation that we do not already know? Isn't it simpler to continue to use the human brain, i.e., best one available? On the other hand, developing a mathematical model of an ecological situation provides arguments of equivalent credibility. Can there be better ecological reasons--maybe respectability is not a valid reason for development of a model.

Is the objective of a model an exercise to counter proposals? Can we build a model to include cost/benefits of an exotic factor in conservation, i.e., bugs vs. fishermen in economic values? Should models offer a wider range of ideas to the decision-makers? -- and highlight features to their attention? A main criticism--assumptions are seldom defined, and a major advantage of modelling is to focus attention on the definition of such assumptions (somewhat having the cart before the horse). A limited and clearly defined objective is essential as the first step to modelling.

The conceptual model is essentially 20th century--we must advance past this stage. The wastage of scientific effort through ineffective research, or through conceptual models which are not sufficiently advanced to develop the subject of research, is equivalent to direct embezzlement of research funds.

As per usual when one or two model builders gather together, there usually follows a spirited discussion; however, in our case the adage was clear that "those who know do not tell; and those who tell do not know!"

Modelling is structuring information:



List of Participants:

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Jesse Logan
Tom Flavell
Bob Thatcher
Scott Overton
Fred Stephen
Jim Colbert
Al Larsen
Alan A. Berryman
Robert F. Luck
Boyd Wickman
Gene Pulley
Evan Nebeker
Garrell E. Lowe
Jim Hansen
Dick Washburn
Barry Hynum
Mike Schomaker
Gary Simmons
Jack Schenk
Les McMullin
Roy Beckwith
Donald L. Dahsten
John Foltz
Mike McManus

WESTERN FOREST INSECT WORK CONFERENCE

MINUTES OF THE FINAL BUSINESS MEETING
March 4, 1976

Chairman Trostle called the meeting to order at 12:40 pm during lunch at Bowman's Mt. Hood Resort, Wemme, Oregon.

Minutes of the initial business meeting and secretary's reports were read and approved.

Motion MSC that the 1978 meeting be held at a Colorado site.

Chairman Trostle expressed gratitude to the program committee consisting of Boyd Wickman, Chairman; LeRoy Kline, Roy Beckwith, and Don Curtis. A round of applause was received from the membership.

Chairman Trostle called for Committee reports:

Common Names Committee: Red McComb reported for this committee. Members are Torgy Torgerson, Chairman; Thelma Finlayson, Wayne Brewer, Larry Stipe, Karel Stoszek, Fay Shon, and Red McComb. The committee met to consider the common name, Southwestern Pine Tip Moth, for Rhyacionia neomexicana (Dyar) submitted by Dan Jennings. This common name was originally submitted to the Entomological Society of America in 1955, but no action was taken. Motion MSC that the name be resubmitted to ESA.

Nominating Committee: Les McMullen submitted the following slate of officers from the nominating committee: Chairman, Rick Johnsey; Secretary-Treasurer, LeRoy Kline; and Councilor Steven Cade. There being no nominations from the floor, the slate of officers was elected by acclamation.

Ethical Practices Committee: Chairman Bill McCambridge explained to members present for the first time that the activities of this committee are to keep an eye on the debaucherous activities of the membership. Bill explained that members arrive with data in hand and great enthusiasm for the purpose of the meeting, but some invariably go astray.

Bill, aided by long-time debauchers Alan Berryman, Bob Dolph and Les McMullen did a herculean job of ferreting out, from our august group, libertines, lechers, degenerates and gay deceivers[1/] for public censure.

In a short span of three days devoted to scientific thought, the following behavior was scrutinized: (1) a depraved lad from Alaska running nude from sauna to pool, back and forth, whilst being watched by two maidens; (2) Bill Ciesla's "boobs" being admired over the bar

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1/ As defined prior to 1940.

by a female scientist. (Report does not indicate what was over the bar.) To go on might unduly titillate the reader. Suffice to say, these candidates and others equally ignoble did not win(?) ultimate distinction.

The chairmanship of the EP Committee and suitable accouterments are passed to Dr. Molly Stock for conduct unbecoming a member of the WFIWC[2/]; viz., excessive raucous, ribald reveling in the halls and in the snow in company with bawdy broads and unsavory boozers.

It was heartening to see the younger generation trying to assert itself. Perhaps we'll see a return of those glorious bad old days yet.

Black Ball Award

Dick Washburn presented the Black Ball Award with the following statement:

"As semi-official historian and with full proxy of Ken Wright, it is my duty to call to your attention that the WFIWC does in fact recognize, of all things, derelict of duty. We do not enjoy being openly critical of our Colleagues. This recognition has been 'awarded' on only one other occasion--to Ken Wright. Therefore many of you may not be aware of this 'mark of distinction.'

The Ethical Practices Committee Chairman is selected on performance. He is expected to devote nearly full time during the evenings and through the nights, if necessary, to thoroughly investigate all incidences that will aid him in selecting his replacement. No one, not even our present chairman, can fulfill this requirement if he has the audacity to bring along his new bride. This is an unpardonable affront on this high office. Therefore, it becomes my painful duty to present to Bill McCambridge, the 'Black Ball' insignia. This symbol of discredit must be worn during the first day, and at the banquet, of the next WFIWC that Bill attends. In addition, the rule specifies that anyone being Black Balled is forever more ineligible for selection as Ethical Practices Chairman. It has been evident your goal was to break the record for winning the most ethical practices awards. That goal cannot now be attained. Sorry!

We are grateful for the opportunity of meeting Virginia, but your timing was inappropriate. You are herewith admonished for causing Virginia the embarrassment of witnessing her husband disgraced in front of this select group of Colleagues."

There being no further business, Chairman Trostle adjourned the meeting at 1:00 pm.

2/ This is two orders of magnitude worse than unbecoming to a lady.

TWENTY-SEVENTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE

WEMME, OREGON

TREASURER'S REPORT

Receipts:			
Registration			
Regular Members	140 @ $8		$1,120.00
Student Members	10 @ $3		30.00
Error during registration			4.00
		Total	$1,154.00
Expenses:			
Bowman's Mt. Hood Resort			$1,218.90
Transportation to Timberline Lodge			313.40
Miscellaneous			25.00
		Total	$1,557.30
Balance:			$ -403.30

WESTERN FOREST INSECT WORK CONFERENCE

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